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TARADCOM LABORATORY TECHNICAL REPORT

R and D

(14) TARADCOM-TR- NO. 12412

(6) TARADCOM SIGNAL ANALYSIS PROGRAM,

(11) SEP[redacted]78

(12) 149 p.

by (10) G. A. Fix

Approved for public release,
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U.S. ARMY TANK-AUTOMOTIVE
RESEARCH AND DEVELOPMENT COMMAND
Warren, Michigan 48090

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ABSTRACT

This report describes an integrated package for evaluating terrain data on the Tektronix 4014 graphics terminals on the Picatinny Arsenal CDC 6500/6600 time sharing system. The program provides the following options: first-to-last point detrending, digital high-pass filter, exponentially weighted running average, no detrending, interpolation, amplitude smoothing, and a GEO window. Terrain data input to the program may be used during processing, rather than the data equations that are contained in the program. Graphics displays include a linear plot of elevation vs. distance, a point plot of amplitude vs. period, and a log-log graph of power spectral density vs. frequency. The model structure, with its capabilities and its limitations, is included along with user instructions for running the program.

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INTRODUCTION

The TARADCOM Signal Analysis Program (TSAP) was developed originally as a BASIC Wang Program by Mr. Robert Daigle of Stevens Institute of Technology and Zoltan J. Janosi of the Applied Research Function of the Survivability Research Division, DRDTA-ZS. The TSAP was converted from BASIC to FORTRAN so as to facilitate running the program in a more commonly known language on the CDC 6500/6600 time sharing system. The following graphics displays were added at the time of conversion: a linear plot of elevation vs. distance, a point plot of amplitude vs. period and a log-log graph of power spectral density vs. frequency.

OBJECTIVE

The objective of this report is to provide a user manual for the TARADCOM Signal Analysis Computer Program with listings of the program, variables, glossary, and flowchart, and instructions for input, output, and running the program.

RUNNING INSTRUCTIONS
FOR
THE SIGNAL ANALYSIS PROGRAM

The following page is a copy of the Tektronix screen showing the interactive command instructions and system responses for running TSAP. After all of the instructions (shown in lower case) have been input, the screen will clear and processing will proceed. Terminal user responses to programmed questions are used as input to TSAP and are the basis for the selection of the available options. The eight questions with possible answers are on page 57-60

After all of the questions have been answered, the screen clears and processing continues.

After the output is finished, the terminal user should key in the following:

BATCH,TEKLD42,LOCAL

E,TEKLD42,S

At this point TEKLD42 is no longer a remote output file. If the same program is to be used, it may be saved at this time. The user should also discard the fi es created earlier in the terminal session; e.g., in this case C45 should be discarded.

```
attack,mmmm,id=ocelot

 PFN IS
 MMMM
 PF CYCLE NO. = 001
..e,mmmm

..save,c45

..catalog,c45,id=ocelot

 INITIAL CATALOG
 RP = 060 DAYS
 CT ID=   OCELOT PFN=C45
 CT CY= 001  00006298 WORDS.:
..etl,1000

..ftn,i=c45,l=0,opt=2

     12.343 CP SECONDS COMPILATION TIME
..begin,tekbch,bchtemp/ciagale,ocelot,lgo,tek45

 INITIAL CATALOG
 RP = 060 DAYS
 CT ID=   OCELOT PFN=A1B2SD
 CT CY= 001  00002112 WORDS.:
  NAME-TEKLD42, DISP-INPUT , ID-NU
..files

--LOCAL FILES--
 $BCHTEMP  $C45      $MMMM     $OUTPUT    LGO
--REMOTE OUTPUT FILES--
  TEKLD42
..attack,tek45,id=ocelot

 PFN IS
 TEK45
 PF CYCLE NO. = 001
..tek45
```

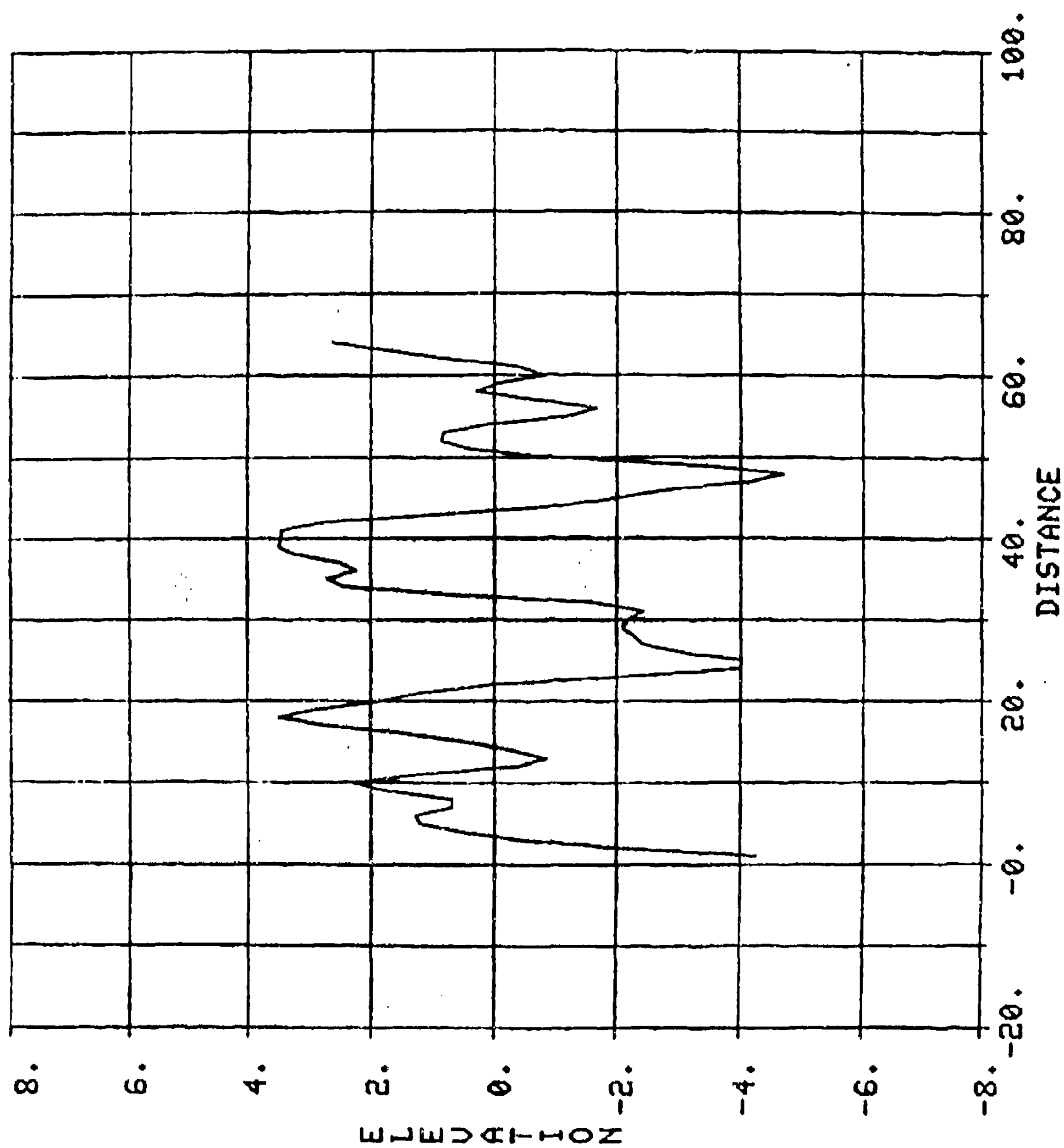
PSD PROGRAM FFT77.7-78.3

```
NUMBER OF TERRAIN POINTS IS EQUAL TO 2**ANS1.
ANS1, AN INTEGER, MUST BE GREATER THAN OR EQUAL TO 1 AND LESS THAN OR
EQUAL TO 8.
ANS1 = 6

SURVEY INTERVAL IN FEET? ALLOWS 4 PLACES PAST DECIMAL.
ANS2 = 1.

ENTER 0 FOR DATA READING,
       1 FOR CARD READING,
      -1 FOR DATA EQUATIONS.
ANS3 = -1

ENTER 1 FOR FIRST TO LAST POINT DETRENDING,
      2 FOR DIGITAL HIGH PASS FILTER,
      3 FOR EXPONENTIALLY WEIGHTED RUNNING AVERAGE,
      4 FOR NO DETRENDING.
ANS4 = 4

DO YOU WANT THE ARRAY PADDED WITH N1 0'S?
ENTER 1 FOR YES,
      2 FOR NO.
ANS5 = 2

DO YOU WANT INTERPOLATION?
ENTER 1 FOR YES,
      2 FOR NO.
ANS6 = 2

DO YOU WANT AMPLITUDE SMOOTHING?
ENTER 1 FOR YES,
      2 FOR NO.
ANS7 = 2

DO YOU WANT A GEO WINDOW?
ENTER 1 FOR YES,
      2 FOR NO.
ANS8 = 1
```

```
THE FOLLOWING DATA EQUATION WAS USED:
  Y=2.5*SIN(-PI/2.+T2/25.)+1.6*SIN(T2/16.)+1.15*SIN(-PI/2.+T22/11.52/11.
5)+.8*SIN(T2/8.)+.6*SIN(-PI/2.+T2/6.)+.4*SIN(T2/4.)
```

RELATIVE MAXIMUM AND MINIMUM PROFILE VALUES

1	-4.26
6	1.28
8	.69
10	2.30
13	-.84
18	3.47
25	-4.82
29	-2.08
31	-2.43
35	2.70
36	2.24
39	3.48
48	-4.70
52	.86
56	-1.67
58	.30
60	-.82
64	2.63



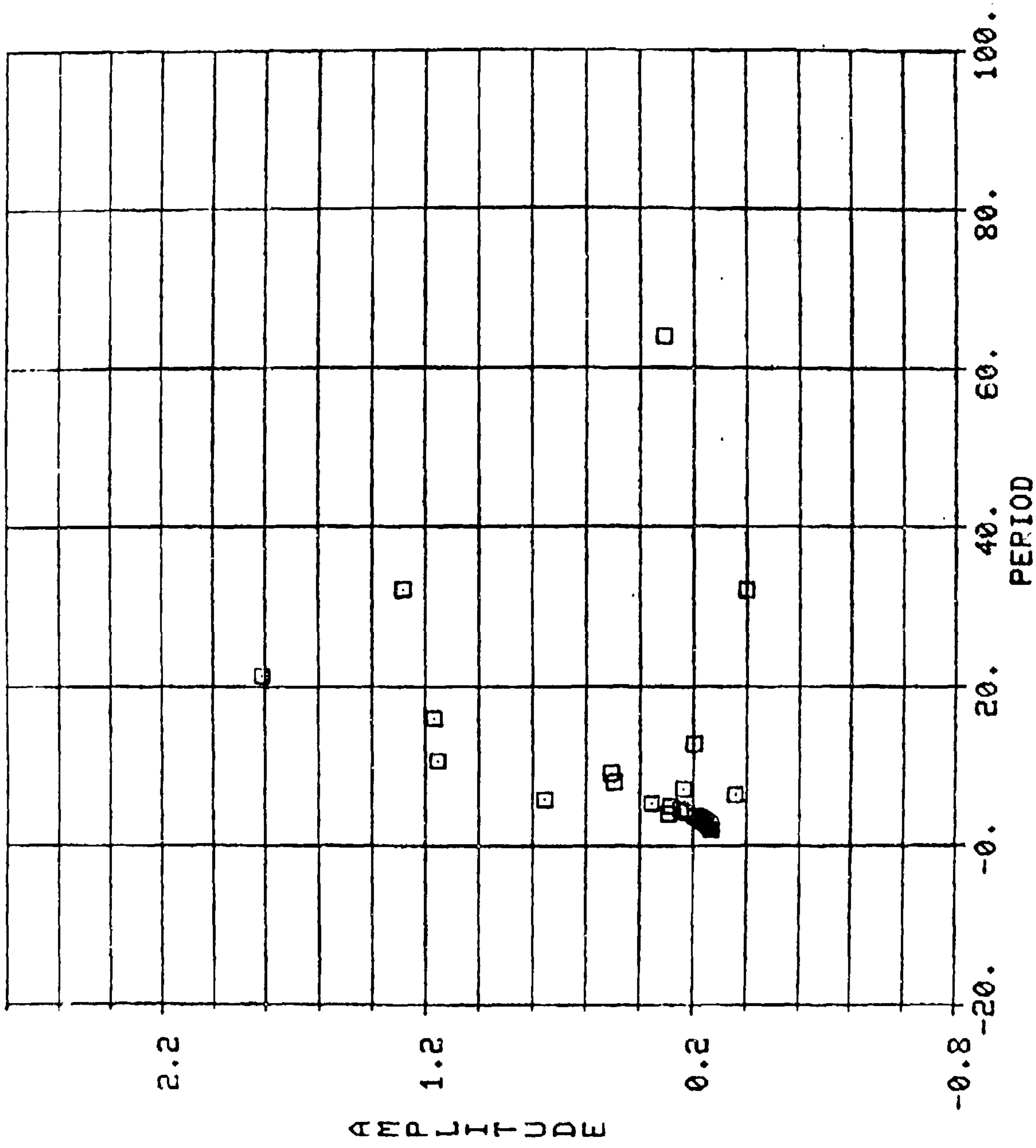
ELEVATION
8.
6.
4.
2.
0.
-2.
-4.
-6.
-8.
DISTANCE
-20.
-0.
20.
40.
60.
80.
100.

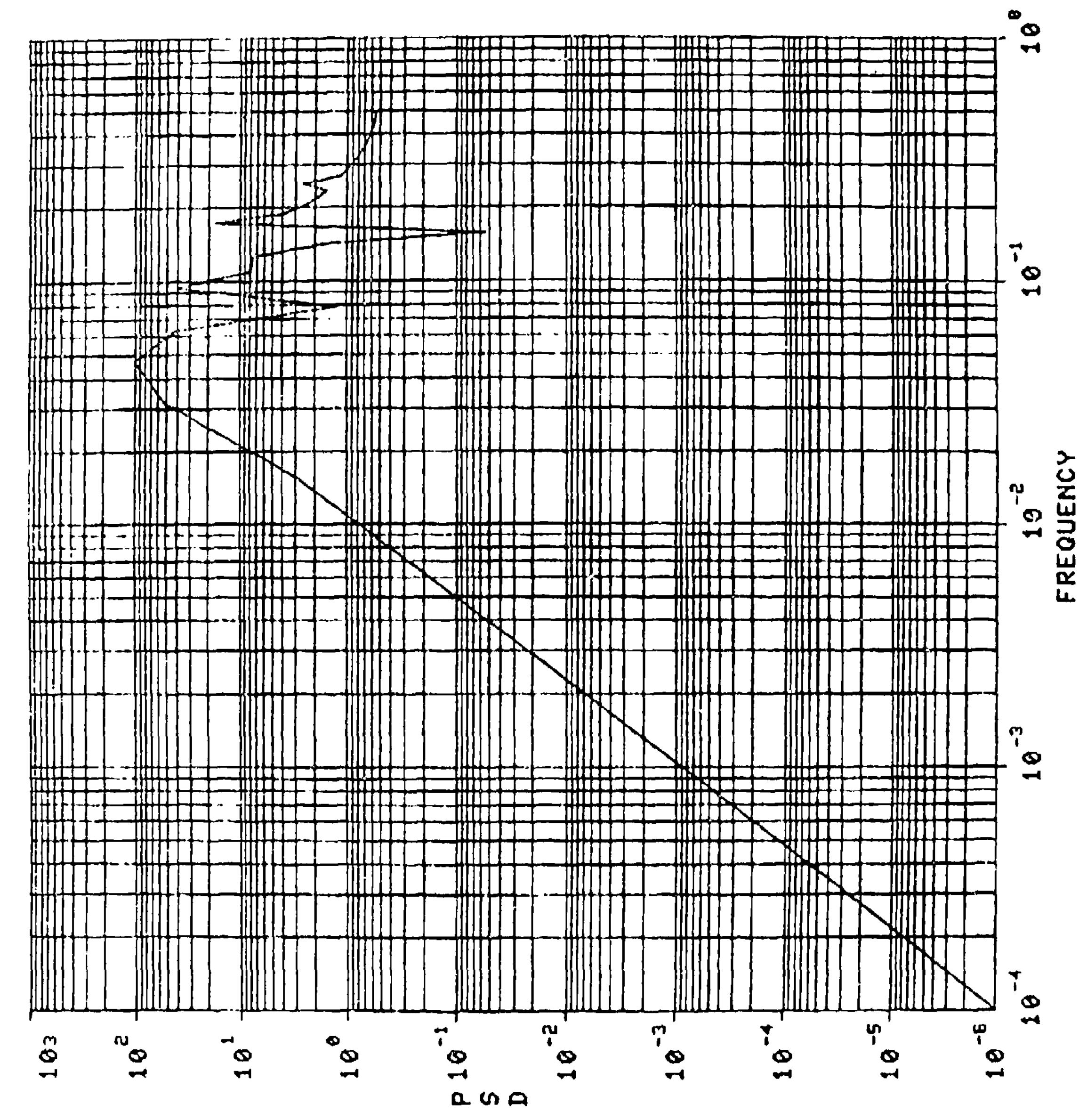
RESULTS WITH UNSMOOTHED F.F.T. AMPLITUDES

RMS = 26.3642 INCHES
AREA UNDER PSD = 4.8269 SQ.FT.

RAW P.S.D. RESULTS

AMPLITUDE	PERIOD	FREQ	PSD
.0000	9999.99	.0001	.000001
.3088	64.00	.0156	3.051327
1.2820	32.00	.0313	52.590653
1.8131	21.33	.0469	105.196496
1.1649	16.00	.0625	43.423355
.1981	12.80	.0781	1.256323
1.1531	10.67	.0938	42.549612
.5069	9.14	.1094	8.223066
.4958	8.00	.1250	7.867344
.2363	7.11	.1406	1.787266
.0415	6.40	.1563	.055188
.7534	5.82	.1719	18.163059
.3569	5.33	.1875	4.076397
.2847	4.92	.2031	2.594495
.2482	4.57	.2188	1.971405
.2242	4.27	.2344	1.609061
.2927	4.00	.2500	2.742232
.1930	3.76	.2656	1.192123
.1820	3.56	.2813	1.060245
.1730	3.37	.2969	.957560
.1654	3.20	.3125	.875882
.1591	3.05	.3281	.809933
.1537	2.91	.3438	.756142
.1492	2.78	.3594	.712002
.1453	2.67	.3750	.675703
.1421	2.56	.3906	.645913
.1394	2.46	.4063	.621638
.1372	2.37	.4219	.602130
.1354	2.29	.4375	.586827
.1341	2.21	.4531	.575314
.1331	2.13	.4688	.567290
.1326	2.06	.4844	.562554
.1324	2.00	.5000	.560988

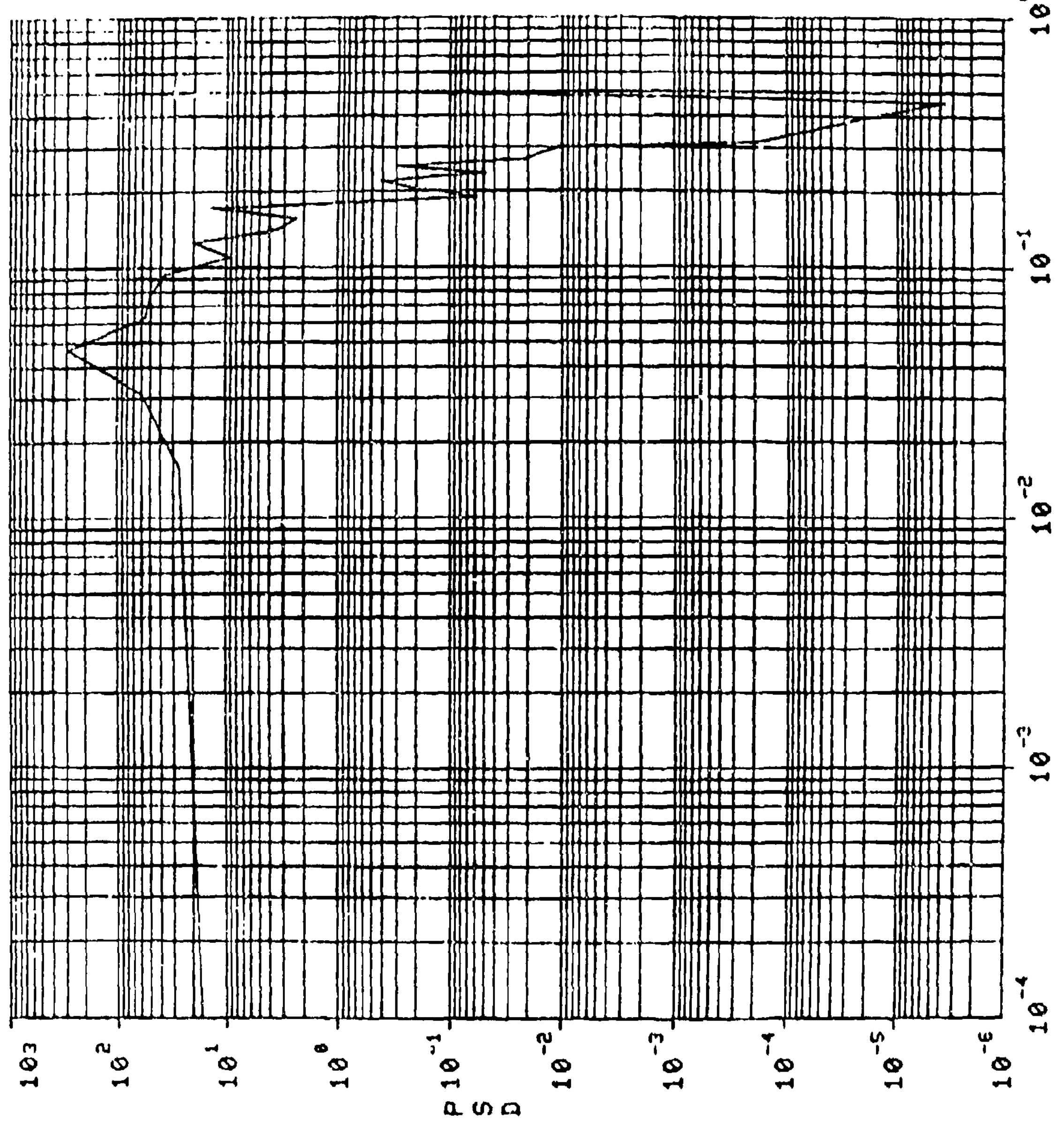

PERIOD
100.
80.
60.
40.
20.
-0.
-20.
AMPLITUDE
2.2
1.2
0.2
-0.8


FREQUENCY
PSD
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

RMS = 37.0157 INCHES
AREA UNDER PSD = 5.5150 SQ.FT.

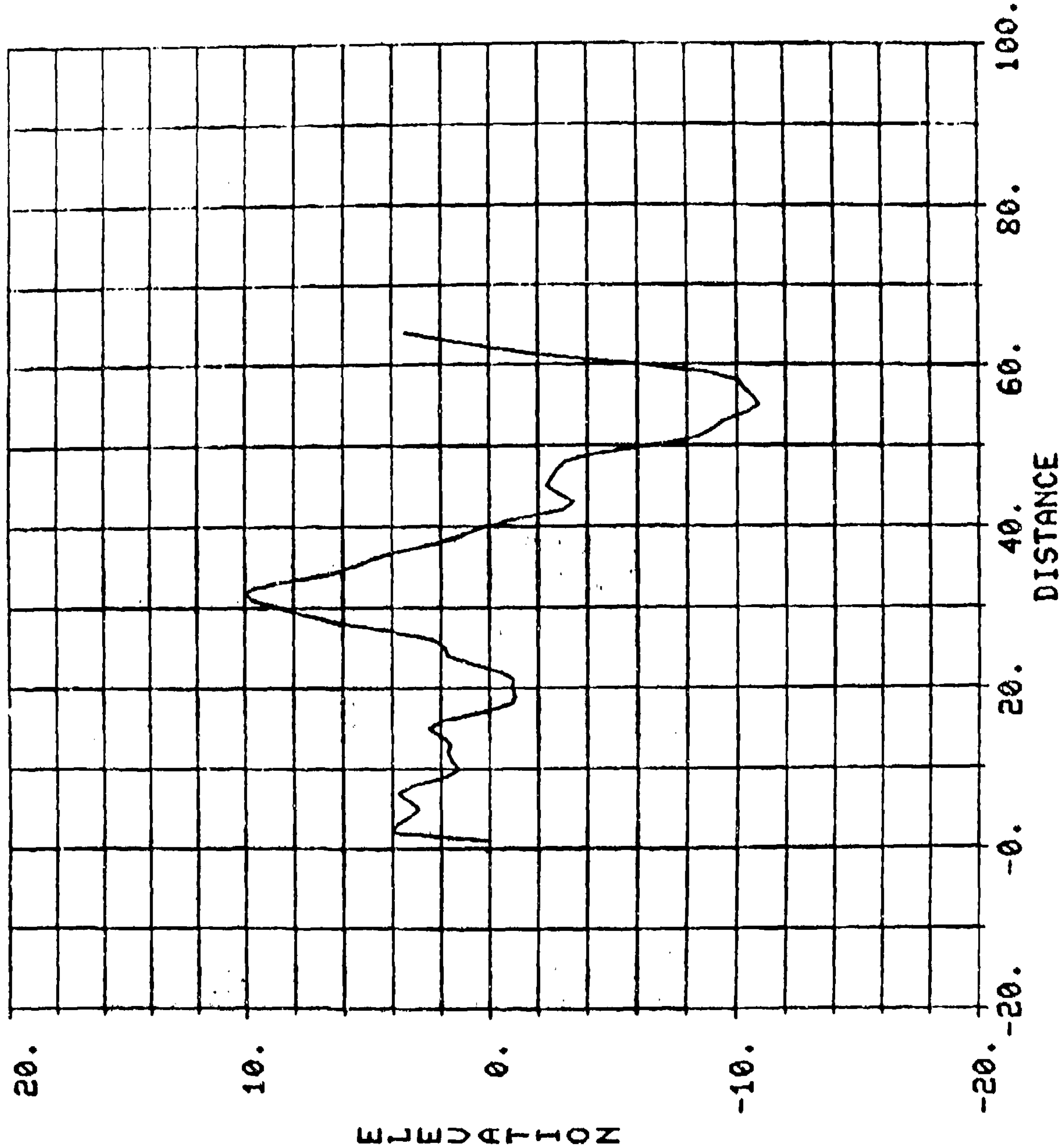
SMOOTH AMPLITUDES USING G.E.O. WINDOW

AMPLITUDE	PERIOD	FREQ	PSD
.7919	9999.99	.0001	17.178177
.9923	64.00	.0156	26.969978
1.5242	32.00	.0313	63.635612
3.3044	21.33	.0469	299.100785
1.4569	16.00	.0625	58.139854
1.3701	12.80	.0781	51.421545
1.1671	10.67	.0938	37.314302
.5816	9.14	.1094	9.266667
.8775	8.00	.1250	21.030710
.3609	7.11	.1406	3.568027
.2565	6.40	.1563	2.408434
.7239	5.82	.1719	14.552069
.0459	5.33	.1875	.057682
.0623	4.92	.2031	.188850
.1246	4.57	.2188	.425600
.0421	4.27	.2344	.048512
.1052	4.00	.2500	.303244
.0276	3.76	.2656	.026530
.0243	3.55	.2813	.016211
.0204	3.37	.2969	.011441
.0026	3.20	.3125	.000128
.0020	3.05	.3281	.000110
.0016	2.91	.3438	.000070
.0013	2.78	.3594	.000046
.0010	2.67	.3750	.000030
.0008	2.56	.3906	.000020
.0007	2.46	.4063	.000013
.0006	2.37	.4219	.000009
.0005	2.29	.4375	.000006
.0004	2.21	.4531	.000004
.0026	2.13	.4688	.000189
.0427	2.06	.4844	.049975
.3414	2.00	.5000	3.192168


PSD
FREQUENCY
10^-4
10^-3
10^-2
10^-1
10^0
103
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6

```
PSD PROGRAM FFT77.7-78.3

NUMBER OF TERRAIN POINTS IS EQUAL TO 2**ANS1.
ANS1, AN INTEGER, MUST BE GREATER THAN OR EQUAL TO 1 AND LESS THAN OR
EQUAL TO 8.
ANS1 = 6

SURVEY INTERVAL IN FEET? ALLOWS 4 PLACES PAST DECIMAL.
ANS2 = 1.

ENTER 0 FOR DATA READING,
      1 FOR CARD READING,
     -1 FOR DATA EQUATIONS.
ANS3 = -1

ENTER 1 FOR FIRST TO LAST POINT DETRENDING,
      2 FOR DIGITAL HIGH PASS FILTER,
      3 FOR EXPONENTIALLY WEIGHTED RUNNING AVERAGE,
      4 FOR NO DETRENDING.
ANS4 = 1

DO YOU WANT THE ARRAY PADDED WITH N1 0'S?
ENTER 1 FOR YES,
      2 FOR NO.
ANS5 = 2

DO YOU WANT INTERPOLATION?
ENTER 1 FOR YES,
      2 FOR NO.
ANS6 = 2

DO YOU WANT AMPLITUDE SMOOTHING?
ENTER 1 FOR YES,
      2 FOR NO.
ANS7 = 2

DO YOU WANT A GEO WINDOW?
ENTER 1 FOR YES,
      2 FOR NO.
ANS8 = 2
```

```
THE FOLLOWING DATA EQUATION WAS USED:
  Y=4.27*SIN(3./2.*PI+T2/42.7)+1.83*SIN(-1./2.*PI+T2/18.3)+.413*SIN(T2/4
.13)
   +3.2*SIN(T2/32.)+1.6*SIN(T2/16.)+.8*SIN(T2/8.)


FIRST TO LAST POINT DETRENDING


RELATIVE MAXIMUM AND MINIMUM PROFILE VALUES
   1        4.64
   5        2.93
   7        3.73
  10        1.28
  12        1.72
  13        1.62
  15        2.48
  19       -1.01
  20        -.98
  21        -.95
  32       10.01
  43       -3.44
  45       -2.33
  55      -10.53
  64        3.47


RMS FROM DE-TRENDED ZERO MEAN TERRAIN DATA = 1773.900 INCHES
```


ELEVATION
20.
10.
0.
-10.
-20.
DISTANCE
-20.
-0.
20.
40.
60.
80.
100.

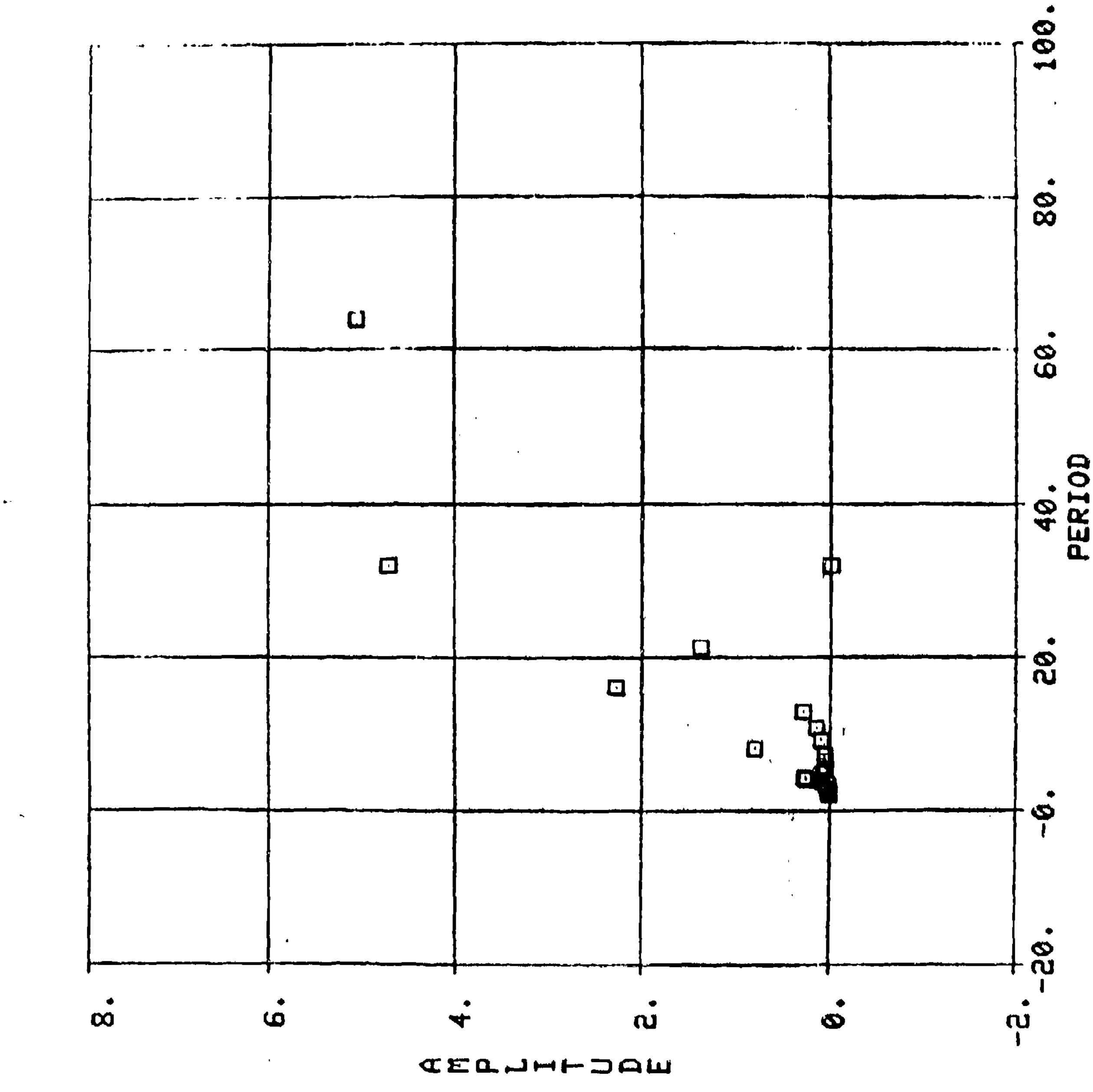
.0132	2.13	.4688	.005609
.0131	2.06	.4844	.005469
.0130	2.00	.5000	.005424

RESULTS WITH UNSMOOTHED F.F.T. AMPLITUDES

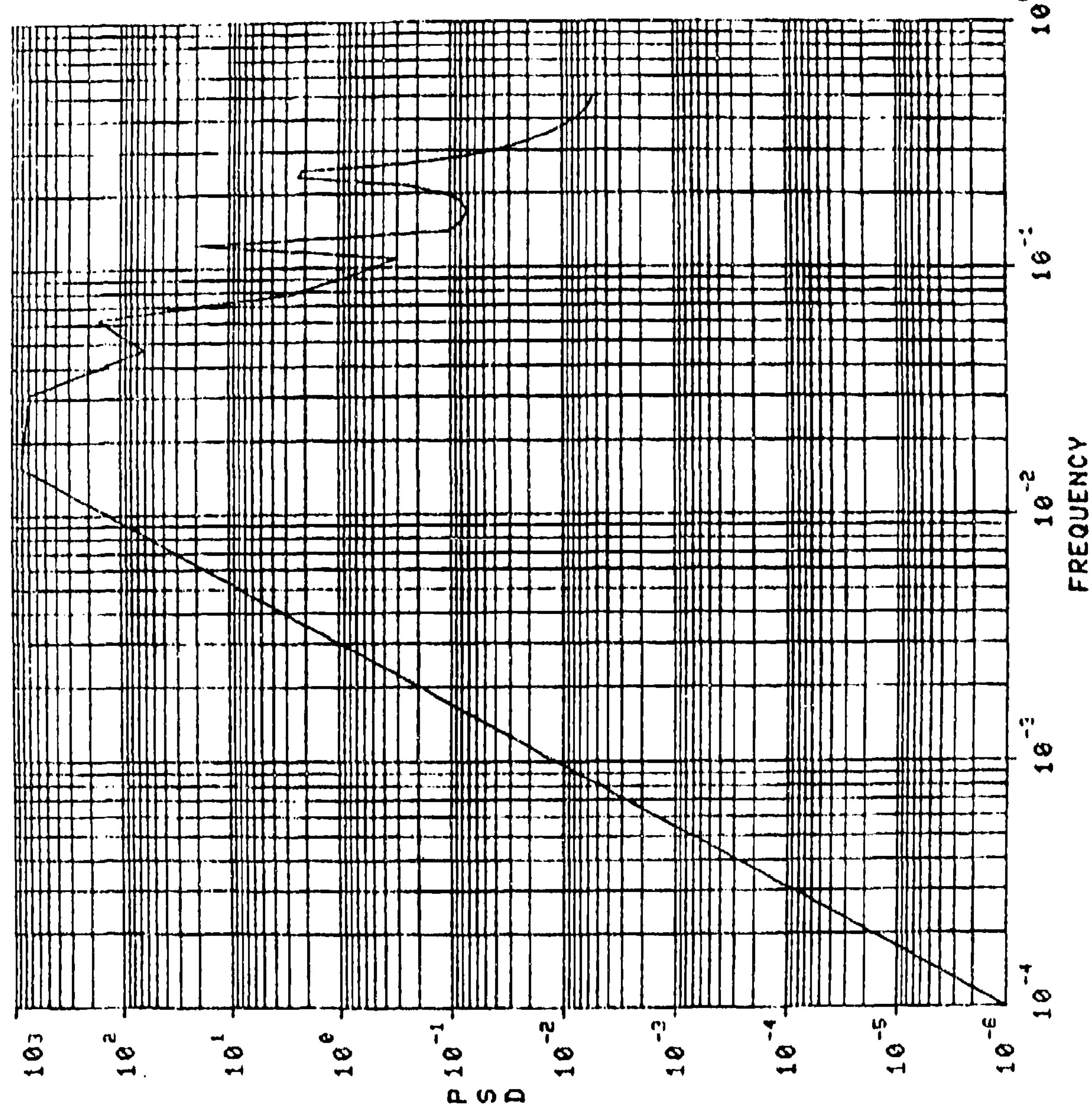
RMS = 63.1766 INCHES
AREA UNDER PSD27.7172 SQ.FT.

RAW P.S.D. RESULTS

AMPLITUDE	PERIOD	FREQ	PSD
.0000	9999.99	.0001	.000001
5.0419	64.00	.0156	813.469217
4.6925	32.00	.0313	704.619345
1.3801	21.33	.0469	60.950728
2.2707	16.00	.0625	165.001759
.2890	12.80	.0781	2.672756
.1513	10.67	.0938	.732771
.0377	9.14	.1094	.305645
.7996	8.00	.1250	20.458387
.0569	7.11	.1406	.103723
.0495	6.40	.1563	.078538
.0472	5.82	.1719	.071440
.0502	5.33	.1875	.080715
.0614			
.0614	4.92	.2031	.120726
.0938	4.57	.2188	.281761
.2683	4.27	.2344	2.312385
.2585	4.00	.2500	2.138204
.0860	3.76	.2656	.236636
.0519	3.56	.2813	.086203
.0376	3.37	.2969	.045161
.0298	3.20	.3125	.028351
.0249	3.05	.3281	.019854
.0216	2.91	.3438	.014969
.0193	2.78	.3594	.011909
.0176	2.67	.3750	.009875
.0163	2.56	.3906	.008466
.0153	2.46	.4063	.007464
.0145	2.37	.4219	.006741
.0139	2.29	.4375	.006220
.0135	2.21	.4531	.005853



AMPLITUDE
8.
6.
4.
2.
0.
-2.
PERIOD
-20.
-0.
20.
40.
60.
80.
100.


PSD
FREQUENCY
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-4
10^-3
10^-2
10^-1
10^0

TARADCOM SIGNAL ANALYSIS PROGRAM SAMPLE
INPUT DATA

..E.P DATA.S

..L.A

100= RPG37 13 NOV 76
110= 401
120=1.0

130=	6.95	6.93	6.99	7.00	6.99	7.04	7.07	7.07	7.10	7.12
140=	7.12	7.14	7.12	7.11	7.10	7.06	7.02	7.00	6.95	6.89
150=	6.84	6.82	6.79	6.73	6.72	6.72	6.69	6.68	6.68	6.68
160=	6.71	6.71	6.71	6.72	6.76	6.80	6.82	6.87	6.87	6.87
170=	6.89	6.91	6.90	6.93	6.93	6.96	7.00	7.03	7.03	7.06
180=	7.06	7.03	7.05	7.08	7.06	7.07	7.04	6.99	7.01	6.99
190=	6.96	6.95	6.93	6.89	6.88	6.88	6.84	6.83	6.83	6.83
200=	6.83	6.81	6.82	6.81	6.78	6.82	6.82	6.81	6.81	6.82
210=	6.83	6.85	6.90	6.90	6.90	6.93	6.94	6.94	6.95	6.92
220=	6.92	6.96	6.94	6.91	6.93	6.94	6.91	6.93	6.92	6.89
230=	6.86	6.83	6.78	6.73	6.72	6.70	6.73	6.74	6.73	6.71
240=	6.72	6.71	6.71	6.73	6.74	6.73	6.72	6.75	6.73	6.71
250=	6.74	6.77	6.73	6.77	6.76	6.75	6.78	6.81	6.81	6.83
260=	6.87	6.88	6.88	6.91	6.91	6.91	6.94	6.99	6.98	7.04
270=	7.05	7.02	7.07	7.13	7.12	7.13	7.17	7.13	7.13	7.16
280=	7.17	7.17	7.22	7.22	7.22	7.24	7.28	7.26	7.25	7.23
290=	7.23	7.28	7.30	7.28	7.28	7.29	7.30	7.28	7.29	7.32
300=	7.33	7.35	7.38	7.41	7.39	7.39	7.40	7.41	7.43	7.44
310=	7.44	7.47	7.49	7.48	7.50	7.54	7.55	7.53	7.57	7.57
320=	7.60	7.69	7.73	7.75	7.79	7.84	7.84	7.88	7.92	7.96
330=	7.98	7.95	7.95	7.97	7.96	7.95	7.95	7.94	7.93	7.89
340=	7.88	7.85	7.79	7.80	7.81	7.81	7.80	7.81	7.86	7.95
350=	7.88	7.89	7.90	7.90	7.94	7.95	8.00	8.02	8.04	8.10
360=	8.15	8.15	8.20	8.21	8.19	8.25	8.27	8.25	8.26	8.27
370=	8.28	8.29	8.32	8.31	8.31	8.35	8.38	8.38	8.44	8.44
380=	8.47	8.49	8.51	8.53	8.54	8.57	8.61	8.63	8.68	8.69
390=	8.71	8.74	8.78	8.78	8.82	8.84	8.84	8.89	8.91	8.93
400=	8.93	8.98	8.98	9.02	9.05	9.09	9.11	9.16	9.17	9.19
410=	9.19	9.19	9.22	9.22	9.22	9.19	9.19	9.21	9.23	9.24
420=	9.27	9.29	9.32	9.31	9.37	9.39	9.38	9.40	9.44	9.41
430=	9.44	9.48	9.46	9.50	9.52	9.54	9.56	9.61	9.60	9.65
440=	9.74	9.76	9.74	9.76	9.81	9.81	9.82	9.83	9.86	9.88
450=	9.87	9.91	9.92	9.93	9.93	9.97	9.96	9.95	9.95	9.95
460=	9.97	9.98	9.99	10.01	10.03	10.02	10.07	10.07	10.06	10.06
470=	10.05	10.07	10.10	10.10	10.12	10.12	10.16	10.17	10.16	10.20
480=	10.20	10.19	10.22	10.23	10.24	10.26	10.29	10.30	10.31	10.36
490=	10.40	10.43	10.50	10.52	10.56	10.58	10.61	10.62	10.66	10.71
500=	10.67	10.68	10.69	10.69	10.71	10.75	10.78	10.79	10.88	10.88
510=	10.86	10.85	10.84	10.80	10.81	10.75	10.71	10.70	10.67	10.63
520=	10.66	10.70	10.71	10.74	10.77	10.80	10.82	10.85	10.86	10.88
530=	10.89									

```
      PROGRAM FET777 (INPUT=75,OUTPUT=75,TAPE20=120,
C***********CHANGE ALL "256"TO"256"*********************************
     &TAPE1=OUTPUT,TAPE33=120,DEBUG,TAPE61=100,TAPE62=100)
      DIMENSION GO(7),A1(256,8),A2(256,8),W1(256,4),W2(256,4)
      DIMENSION K22(2),K33(2),KK(72),XX(41,10)
      DIMENSION RAY(2,100),XLAB(1),YLAB(1)
      DIMENSION RAY1(2,100),XLAB1(1),YLAB1(1)
      DIMENSION RAY2(2,100),XLAB2(1),YLAB2(1)
      INTEGER ANS1,ANS3,ANS4,ANS5,ANS6,ANS7,ANS8
      INTEGER R,C,R0,C0,R1,C1,R2,C2,R3,C3,P2
      REAL K22,K33,K9,KK
      DATA XX/410*0./
      DATA GO/-.1476,-.1707,-.1817,1.,-.1817,-.1707,-.1476/
      CALL CONNEC(5LINPUT)
      CALL CONNEC(6LOUTPUT)
      CALL INITT(300)
      CALL CHRSIZ(3)
C$    STORES(W1,W2,I1,I2,J,K,J1,K1)
      PI=3.14159265
      PRINT(1,100)
100   FORMAT(16X,"PSO PROGRAM FET77,7-78,3",///)
      PRINT(1,120)
120   FORMAT(1X,"NUMBER OF TERRAIN POINTS IS EQUAL TO 2**ANS1,",/,1X,
     &"ANS1, AN INTEGER, MUST BE GREATER THAN OR EQUAL TO 1 AND LESS THA
     &N OR",/,1X,"EQUAL TO 8,",/,1X,"ANS1 = ")
      READ *, ANS1
C     WRITE(2,150) ANS1
      IF(ANS1.LE.1)GOTO 9999
150   FORMAT(1X,I3)
      PRINT(1,170)
170   FORMAT(1X,"SURVEY INTERVAL IN FEET? ALLOWS 4 PLACES PAST DECIMAL,"
     &,/,1X,"ANS2 = ")
      READ *,ANS2
C     WRITE(2,180)ANS2
180   FORMAT(1X,F9.4)
      PRINT(1,200)
200   FORMAT(1X,"ENTER 0 FOR DATA READING,",/,7X,"1 FOR CARD READING,",
     &/,6X,"-1 FOR DATA EQUATIONS,",/,1X,"ANS3 = ")
```

```
      READ *, ANS3                                                      000480
C     WRITE(2,210) ANS3                                                 000490
210   FORMAT(1X,I2)                                                     000500
      PRINT(1,220)                                                      000510
  220 FORMAT(1X,"ENTER 1 FOR FIRST TO LAST POINT DETRENDING,",/,7X,"2 FO000520
     &R DIGITAL HIGH PASS FILTER,",/,7X,"3 FOR EXPONENTIALLY WEIGHTED RU000530
     &NNING AVERAGE,",/,7X,"4 FOR NO DETRENDING.",/,1X,"ANS4 = ")       000540
      READ *,ANS4                                                       000550
C     WRITE(2,330) ANS4                                                 000560
330   FORMAT(1X,I2)                                                     000570
      PRINT(1,340)                                                      000580
340   FORMAT(1X,"DO YOU WANT THE ARRAY PADDED WITH N1 OBS?",/,1X,       000590
     &"ENTER 1 FOR YES,",/,7X,"2 FOR NO.",/,1X,"ANS5 = ")               000600
      READ *, ANS5                                                      000610
C     WRITE(2,350) ANS5                                                 000620
350   FORMAT(1X,I2)                                                     000630
      PRINT(1,370)                                                      000640
  370 FORMAT(1X,"DO YOU WANT INTERPOLATION?",/,1X,"ENTER 1 FOR YES,",/,7000650
     &X,"2 FOR NO.",/,1X,"ANS6 = ")                                     000660
      READ *,ANS6                                                       000670
C     WRITE(2,390) ANS6                                                 000680
390   FORMAT(1X,I2)                                                     000690
      PRINT(1,400)                                                      000700
400   FORMAT(1X,"DO YOU WANT AMPLITUDE SMOOTHING?",/,1X,                000710
     &"ENTER 1 FOR YES,",/,7X,"2 FOR NO.",/,1X,"ANS7 = ")               000720
      READ *, ANS7                                                      000730
C     WRITE(2,450) ANS7                                                 000740
450   FORMAT(1X,I2)                                                     000750
      PRINT(1,460)                                                      000760
  460 FORMAT(1X,"DO YOU WANT A GEO WINDOW?",/,1X,"ENTER 1 FOR YES,",/,7X000770
     &,"2 FOR NO.",/,1X,"ANS8 = ")                                      000780
      READ *,ANS8                                                       000790
C     WRITE(2,470)ANS8                                                  000800
470   FORMAT(1X,I2)                                                     000810
      CALL HDCOPY                                                       000820
      CALL NEWPAG                                                       000830
      CALL HOME                                                         000840
C     REWIND 2                                                          000850
```

```
C     READ(2,150)ANS1                                          000860
C     READ(2,180)ANS2                                          000870
C     READ(2,210)ANS3                                          000880
C     READ(2,330)ANS4                                          000890
C     READ(2,350)ANS5                                          000900
C     READ(2,390)ANS6                                          000910
C     READ(2,450)ANS7                                          000920
C     READ(2,470)ANS8                                          000930
      WRITE(20,800)                                            000940
800   FORMAT(1X,20X,"PSD PROGRAM")                             000950
      N1=2**ANS1                                               000960
      E=36./ANS2                                               000970
      IE=INT(E)                                                000980
      WRITE(20,810) ANS2                                       000990
810   FORMAT(1X,"SURVEY INTERVAL = ",F9.4,"FEET")              001000
      IF(ANS4.NE.3)GOTO 1440                                   001010
      N1=N1+2*E                                                001020
C*****CARD READING WILL BE INTRODUCED AT A LATER TIME           001030
1440  IF(ANS3.EQ.1)GOTO 9999                                   001040
      IF(ANS3.EQ.0)GOTO 1600                                   001050
C                                                              001060
C     FOR ANS3=-1, INITIALIZE TERRAIN DATA ARRAY               001070
C                                                              001080
      I1=1                                                     001090
      IF(ANS4.GE.2)GOTO 1470                                   001100
1470  NZ=N1                                                    001120
      DO 1560 I=I1,NZ                                          001130
C     FOR NO PADDING                                           001140
      IF(ANS5.EQ.2)GOTO 1510                                   001150
      I2=N1+1                                                  001160
      CO=1+INT((I2-.5)/256)                                    001170
      RO=I2-256*(CO-1)                                         001180
      A1(RO,CO)=0                                              001190
1510  X=I-1                                                    001200
      T2=2*PI*X*ANS2                                           001210
      I2=I+1-I1                                                001220
      CO=1+INT((I2-.5)/256)                                    001230
      RO=I2-256*(CO-1)                                         001240
```

```
C
C       THE DATA EQUATIONS WHICH FOLLOW IMMEDIATELY MAY BE SUBJECT TO
C       REPLACEMENT.
C
 1550 A1(RO,CO)=2.5*SIN(-PI/2.+T2/25.)+1.6*SIN(T2/16.)
     &+1.15*SIN(-PI/2.+T2/11.5)+.8*SIN(T2/8.)+.6*SIN(-PI/2.+T2/6.)
     &+.4*SIN(T2/4.)
      A2(RO,CO)=A1(RO,CO)
 1560 CONTINUE
      WRITE(1,1570)
 1570 FORMAT(1X,"THE FOLLOWING DATA EQUATION WAS USED:",/,3X,
     &"Y=2.5*SIN(-PI/2.+T2/25.)+1.6*SIN(T2/16.)+1.15*SIN(-PI/2.+T22/11.5
     &2/11.5)+.8*SIN(T2/8.)+.6*SIN(-PI/2.+T2/6.)+.4*SIN(T2/4.)")
C
C       FOR CASES WITHOUT ZERO PADDING.
C
      IF(ANS5.EQ.2)GOTO 1580
      ANS1=ANS1+1
      N1=2**ANS1
 1580 CONTINUE
C
C       FOR CASES OTHER THAN DATA READING
C
      IF(ANS6.EQ.2)GOTO 1680
      GOTO 1650
C**********************************************************************
C**********************************************************************
C
C       READ TERRAIN PROFILE DATA.
C
 1600 DO 1620 JB=1,4)
      READ(33,1610)(XX(JB,JG),JG=1,10)
 1610 FORMAT(10F6.2)
 1620 CONTINUE
      JB=1
      JG=1
      NZ=N1+1
```

```
      DO 1645 IO=1,NZ
      I1=IO
      IF(ANS4.GE.2)GOTO 1630
      I1=IO-IF
      IF(I1.LT..5)GOTO 1640
 1630 CO=INT((I1-1.)/256)+1
      RO=I1-256*(CO-1)
      A1(RO,CO)=XX(JB,JG)
      A2(RO,CO)=XX(JB,JG)
 1640 JG=JG+2
      IF(JG.GT.10)JR=JR+1
      IF(JG.GT.10)JG=1
 1645 CONTINUE
C
C     SPREAD OUT ARRAY TO TWICE ITS ORIGINAL LENGTH.
C
 1650 DO 1670 K=1,N1
      I=N1+2-K
      CO=1+INT((I-1.)/256)
      RO=I-256*(CO-1)
      J=2*I-1
      C1=1+INT((J-1.)/256)
      R1=J-256*(C1-1)
      A1(R1,C1)=A1(RO,CO)
 1670 CONTINUE
      ANS1=ANS1+1
      N1=2**ANS1
      ANS2=ANS2/2
C
C     1ST AND LAST POINT LINEAR INTERPOLATION
C
      A1(2,1)=.5*(A1(1,1)+A1(3,1))
      I1=N1-1
      C1=1+INT((I1-1.)/256)
      R1=I1-256*(C1-1)
      I2=N1
      C2=1+INT((I2-1.)/256)
      R2=I2-256*(C2-1)
```

```
      I3=N1+1
      C3=1+INT((I3-1.)/256)
      R3=I3-256*(C3-1)
      A1(R2,C2)=.5*(A1(R1,C1)+A1(R3,C3))
C
C     FOR CASES OF INTERPOLATION
C
      IF(ANS6.EQ.1)GOTO 3200
1680  CONTINUE
C
C     SELECT DETRENDING METHOD
C
      GOTO(3900,3600,4050,1690)ANS4
C*****************************************************************************
C*****************************************************************************
C     RETURN TO 1690 AFTER DETRENDING
C     THE FOLLOWING DO LOOP COMPUTES THE AVERAGE VALUE OF THE
C     GIVEN TERRAIN POINTS.  THIS WILL THEN BE SUBTRACTED FROM
C     EACH INDIVIDUAL POINT VALUE SO THAT THE NEW AVERAGE OF
C     THE TERRAIN POINTS WILL BE ZERO.
C     THIS IS DONE FOR THE PURPOSE OF INITIALIZING THE VALUES
C     USED IN THE FAST FOURIER TRANSFORMATION.  (ASK ZOLTAN.)
C     CHECK LATER FOR POINT OF ENTRY INTO THIS PROGRAM SECTOR.
C
1690  ST=A1(1,1)
C
C     COMPUTE AVERAGE
C
      DO 1700 IO=2,N1
      CO=(INT((IO-1.)/256)+1)
      RO=IO-256*(CO-1)
C
C     ST IS THE SUMMATION OF THE VALUES OF THE TERRAIN POINTS
C
      ST=ST+A1(RO,CO)
1700  CONTINUE
      Y=ST/(N1)
      A1(1,1)=A1(1,1)-Y
```

```
      A1(2,1)=A1(2,1)-Y
      B1=A1(1,1)
      B2=A1(2,1)
      X=B1*B1+B2*B2
C
C     Y DESIGNATES THE AVERAGE TERRAIN POINT VALUE
C
      WRITE(20,1710)
1710  FORMAT(1X,"RELATIVE MAXIMUM & MINIMUM PROFILE VALUES")
      PRINT(1,1720)
1720  FORMAT(///,1X,"RELATIVE MAXIMUM AND MINIMUM PROFILE VALUES",/)
      IO=1
      WRITE(20,1730) IO,B1
1730  FORMAT(1X,I3,5X,F6.2)
      PRINT(1,1740)IO,B1
1740  FORMAT(1X,I3,5X,F6.2)
      RAY1(1,1)=IO
      RAY1(2,1)=B1
      IO1=IO
C
C     SUBTRACT AVERAGE FROM INDIVIDUAL PTS.
C
      DO 1800 IO=3,N1
      CO=(INT((IO-1.)/256)+1)
      RO=IO-256*(CO-1)
      A1(RO,CO)=A1(RO,CO)-Y
      B3=B2-B1
      B4=A1(RO,CO)-B2
      IF(B3*B4.GT.0)GOTO 1770
C
C     PRINT RELATIVE MAX OR MIN
C
      WRITE(20,1730)IO-1,B2
      PRINT(1,1740)IO-1,B2
1770  X=X+(A1(RO,CO))**2
      IO1=IO1+1
      RAY1(1,IO1)=IO-1
      RAY1(2,IO1)=B2
```

```
      R1=R2
      R2=A1(R0,C0)
 1800 CONTINUE
      WRITE(20,1730) N1,R2
      PRINT(1,1740)N1,R2
      I01=I01+1
      RAY1(1,I01)=N1
      RAY1(2,I01)=R2
      XLABI(1)=8HDISTANCE
      YLABI(1)=9HELEVATION
      CALL HDCOPY
      CALL NEWPAG
      CALL INITT(300)
      CALL GPLOT(RAY1,I01,XLABI,8,YLABI,9,2,,1.,10.,10.,1.,1.,IFLG,G.)
      CALL HDCOPY
      X=12.*SQRT(X/N1)
      WRITE(1,1850)X
      WRITE(20,1850) X
 1850 FORMAT(///,1X,"RMS FROM DE-TRENDED ZERO MEAN TERRAIN DATA = ",
     &F8.3,1X,"INCHES")
      N2=N1/2
      DO 1900 I=1,N2
C
C     THIS DO LOOP SPLITS THE DATA INTO TWO ARRAYS. THIS MAY BE
C     UNNECESSARY IN CDC BUT IS INCLUDED AS A PRECAUTION
C
      C0=1+INT((I-1.)/256)
      R0=I-256*(C0-1)
      I2=2*I
      C1=1+INT((I2-1.)/256)
      R1=I2-256*(C1-1)
      C2=1+INT((I2-2.)/256)
      R2=I2-1-256*(C2-1)
      A1(R0,C0)=A1(R2,C2)
      A2(R0,C0)=A1(R1,C1)
 1900 CONTINUE
C
```

```
C     COMPUTATION OF THE FAST FOURIER TRANSFORMATION FOLLOWS.
C     BOB DAIGLE DERIVED THE ALGORITHM FROM A MORE COMPLEX BENDIX
C     PROGRAM. FOR MORE INFORMATION ON THE BENDIX PROGRAM
C     CONTACT TOM WASHBURN.  FOR MORE INFORMATION ON THE
C     FAST FOURIER TRANSFORMATION CONTACT ZOLTAN JANOSI.
C
      N=N1
      N2=N/2
C
C     SAVE N1
C
      N9=N1
C
C     W**0
C
      W1(1,1)=1.
      W2(1,1)=0.
C
C     W**1
C
      W1(2,1)=COS(2*PI/N2)
      W2(2,1)=-SIN(2*PI/N2)
      I=2
C
C     PRINT(1,1940)W1(2,1),W2(2,1)
1940  FORMAT(1X,F3.1,3X,F3.1)
C     COMPUTE W**2 THRU W**(N/2)
C
      N4=N1/4
      DO 2000 I=3,N4
      K=1+INT((I-.5)/256)
      J=I-256*(K-1)
      K1=1+INT((I-1.5)/256)
      J1=I-1-256*(K1-1)
      W1(J,K)=W1(J1,K1)*W1(2,1)-W2(J1,K1)*W2(2,1)
      W2(J,K)=W2(J1,K1)*W1(2,1)+W1(J1,K1)*W2(2,1)
C
```

```
C     PRINT(1,1950)I,W1(J,K),W2(J,K)
1950  FORMAT(1X,I4,5X,F7.4,5X,F7.4)
C
      WRITE(20,1950)I,W1(J,K),W2(J,K)
2000  CONTINUE
      L=1
      ANS1=ANS1-1
2050  M=0
C
C     PRINT(1,2100) L
2100  FORMAT(1X,I3)
C
      P2=INT(2**(ANS1-L)+0.5)
      K=0
C
C     REVERSE BITS OF K
C
2110  K1=K
      K8=0
      K9=N4
C
C     THIS PROGRAM SEGMENT WILL REVERSE BITS OF K AND STORE IN K8
C
      DO 2200 I=1,ANS1
      K2=INT(K1/2.)
      IF((K1-2*K2).LT.0.5)GOTO 2170
      K8=K8+K9
 2170 K9=K9/2
      K1=K2
 2200 CONTINUE
C
C     PRINT(1,2240) K,K8
2240  FORMAT(1X,I4,3X,I4)
C
C     WRITE(1,2240) K, K8
      I=K8*P2+1
      I2=1+INT((I-.5)/256)
      I1=I-256*(I2-1)
```

```
      K22(1)=W1(I1,I2)
      K22(2)=W2(I1,I2)
      N1=0
 2250 J=K+N1+P2+1
      J2=1+INT((J-.5)/256)
      J1=J-256*(J2-1)
      K33(1)=A1(J1,J2)*K22(1)-A2(J1,J2)*K22(2)
      K33(2)=A1(J1,J2)*K22(2)+A2(J1,J2)*K22(1)
      I=K+N1+1
      I2=1+INT((I-.5)/256)
      I1=I-256*(I2-1)
      A1(J1,J2)=A1(I1,I2)-K33(1)
      A2(J1,J2)=A2(I1,I2)-K33(2)
      A1(I1,I2)=A1(I1,I2)+K33(1)
      A2(I1,I2)=A2(I1,I2)+K33(2)
C
C     PRINT(1,2260)I,J,A1(J1,J2),A2(J1,J2),A1(I1,I2),A2(I1,I2)
 2260 FORMAT(1X,I4,3X,F8.2,3X,F8.2,5X,I4,F8.2,3X,F8.2)
C
      WRITE(20,2260)I,J,A1(J1,J2),A2(J1,J2),A1(I1,I2),A2(I1,I2)
      N1=N1+1
      IF(N1.LT.P2)GOTO 2250
      K=K+2*P2
      M=M+1
      IF(M.LT.2**(L-1))GOTO 2110
      L=L+1
      IF(L.LE.ANS1)GOTO 2050
C
C     THE FOLLOWING DO LOOP REVERSES DIGITS TO GET A(I)'S IN PROPER
C     ORDER.
C
      DO 2300 J=1,N2
      K=J-1
      K1=K
      K8=0
      K9=N4
```

```
      DO 2290 I=1,ANSI
      K2=INT(K1/2.)
      IF((K1-2*K2).LT.0.5)GOTO 2280
      K8=K8+K9
 2280 K9=K9/2.
      K1=K2
 2290 CONTINUE
      IF(K8.LE.K)GOTO 2300
C
C     INTERCHANGE A(J) AND A(J8)
C
      J8=K8+1
      J7=1+INT((J8-.5)/256)
      J6=J8-256*(J7-1)
      J2=1+INT((J-.5)/256)
      J1=J-256*(J2-1)
      X=A1(J1,J2)
      A1(J1,J2)=A1(J6,J7)
      A1(J6,J7)=X
      X=A2(J1,J2)
      A2(J1,J2)=A2(J6,J7)
      A2(J6,J7)=X
 2300 CONTINUE
      C1=1+INT((N2+.5)/256)
      R1=N2+1-256*(C1-1)
      A1(R1,C1)=A1(1,1)
      A2(R1,C1)=A2(1,1)
      DO 2400 K=1,N4
      M=N2+2-K
      SZ=SIN(2*PI*(K-1)/N)
      CZ=COS(2*PI*(K-1)/N)
      C1=1+INT((K-.5)/256)
      R1=K-256*(C1-1)
      C2=1+INT((M-.5)/256)
      R2=M-256*(C2-1)
      Z1=.5*(A1(R1,C1)+A1(R2,C2))-.5*SZ*(A1(R1,C1)-A1(R2,C2))+
     &.5*CZ*(A2(R1,C1)+A2(R2,C2))
      Z2=.5*(A2(R1,C1)-A2(R2,C2))-.5*SZ*(A2(R1,C1)+A2(R2,C2))-
```

```
     &.5*CZ*(A1(R1,C1)-A1(R2,C2))
      SZ=SIN(2*PI*(M-1)/N)
      CZ=COS(2*PI*(M-1)/N)
      Z3=.5*(A1(R2,C2)+A1(R1,C1))-.5*SZ*(A1(R2,C2)-A1(R1,C1))+
     &.5*CZ*(A2(R2,C2)+A2(R1,C1))
      Z4=.5*(A2(R2,C2)-A2(R1,C1))-.5*SZ*(A2(R2,C2)+A2(R1,C1))-
     &.5*CZ*(A1(R2,C2)-A1(R1,C1))
      A1(R1,C1)=Z1
      A2(R1,C1)=Z2
      A1(R2,C2)=Z3
      A2(R2,C2)=Z4
 2400 CONTINUE
      N3=N2+1
      CALL NEWPAG
      CALL CHRSIZ(3)
      CALL HOME
      PRINT(1,2450)
 2450 FORMAT(//,27X,"RAW P.S.D. RESULTS",//,15X,"AMPLITUDE   PERIOD
     &  FREQ              PSD")
      P1=0.
      K=0
      F1=0.
      A=0.
      PZ=9999.99
      P=PZ
      F=0.
      P4=0.
C
C     PRINT *,"X,I1,I2,A1,A2"
C
      DO 2600 I=1,N3
C
C     PERIOD AND FREQUENCY
C
 2460 IF(I.EQ.1)GOTO 2470
      P=ANS2*N/(I-1.)
 2470 F=1./P
C
```

```
C     AMPLITUDE
C
      I2=1+INT((I-.5)/256)
      I1=I-256*(I2-1)
C
C     PRINT *,X,I1,I2,A1(I1,I2),A2(I1,I2)
      X=A1(I1,I2)**2+A2(I1,I2)**2
C
C     COMPUTE AMPLITUDE
C
      A=SQRT(X)*2/N
C
C     COMPUTE POWER SPECTRAL DENSITY
C
      G=X*2*ANS2/N
C
C     STORE UNSMOOTHED PSD
C
      A1(I1,I2)=G
      P1=P1+G
      P4=P4+G
      F1=F1+F
      K=K+1
      IF(N/I.LT.1.999)GOTO 2490
C
C     MAINTAIN MIN 1 FT PERIOD INTERVAL FOR PRINTOUT
C
C     IF(PZ-N/I.LT.1.)GOTO 2460
C
 2490 F=F1/K
      IF(F.LT..0001)GOTO 2500
      P=1./F
 2500 G=P4
      IF(G.LT.0.000001)G=0.000001
      IF(P.GT.9000.)RAY2(1,I)=2**ANS1
      IF(P.GT.9000.)RAY2(2,I)=0.
      IF(P.GT.9000.)GOTO 2510
      RAY2(1,I)=P
```

```
      RAY2(2,I)=A
 2510 RAY(1,I)=F
      RAY(2,I)=G
      WRITE(1,2530)A,P,F,G
 2530 FORMAT(15X,F6.4,5X,F7.2,5X,F6.4,4X,F11.6)
      WRITE(20,2550)A,P,F,G
 2550 FORMAT(1X,4(F7.2,3X))
      RAY(1,I)=F
      RAY(2,I)=G
      P4=0.
      K=0
      F1=0
      A=0.
      PZ=N/I
 2600 CONTINUE
C
C     AREA UNDER PSD
C
      P3=P1/(ANS2*N)
      P1=12.*SQRT(P3)
      WRITE(1,2700)
 2700 FORMAT(///,1X,"RESULTS WITH UNSMOOTHED F.F.T. AMPLITUDES")
      WRITE(1,2750)P1,P3
 2750 FORMAT(/,1X,"RMS = ",F9.4,1X,"INCHES",/,1X,"AREA UNDER PSD = ",
     &F9.4,1X,"SQ.FT.")
      CALL HDCOPY
      CALL NEWPAG
      XLAB2(1)=6HPERIOD
      YLAB2(1)=9HAMPLITUDE
      CALL INITT(300)
      CALL GPLOT(RAY2,N3,XLAB2,6,YLAB2,9,2.,1.,10.,10.,1.,1.,IFLG,1.)
      CALL HDCOPY
      CALL NEWPAG
      XLAB(1)=9HFREQUENCY
      YLAB(1)=3HPSD
      CALL NEWPAG
      CALL INITT(300)
      CALL GPLOT(RAY,N3,XLAB,9,YLAB,3,2.,1.,10.,10.,2.,2.,IFLG,0.)
```

```
      CALL HDCOPY
      CALL NEWPAG
      CALL CHRSIZ(3)
      CALL HOME
      IF(ANS8.EQ.2)GOTO 9999
      PRINT(1,2850)
 2850 FORMAT(//,17X,"SMOOTH AMPLITUDES USING G.E.O. WINDOW",//,
     &15X,"AMPLITUDE",3X,"PERIOD",7X,"FREQ",11X,"PSD")
      PI=0.
C
C     SMOOTH AMPLITUDES USING GEO WINDOW
C
      X=SQRT(.856)
      DO 3150 I=1,N3
      A=0.
      B=0.
      DO 3050 K=1,7
      J=I+(K-4)
      IF(J.GT.0)GOTO 2900
      J=J+N3
      GOTO 3000
 2900 IF(J.LT.N3+.5)GOTO 3000
      J=J-N3
 3000 CO=1+INT((J-.5)/256)
      RO=J-256*(CO-1)
      A=A+GO(K)*A1(RO,CO)
      B=B+GO(K)*A2(RO,CO)
 3050 CONTINUE
      X=A*A+B*B
      G=.856*X*2*ANS2/N
      IF(G.LT..000001)G=.000001
      A=SQRT(X)*2/N
      P=9999.99
      IF(I.LT.1.5)GOTO 3100
      P=ANS2*N/(I-1.)
 3100 F=1./P
      WRITE(1,2530)A,P,F,G
      RAY(1,I)=F
```

```
      RAY(2,I)=G
      P1=P1+G
 3150 CONTINUE
      P3=P1/(ANS2*N)
      P1=12.*SQRT(P3)
C
C     PRINT RMS, AREA UNDER PSD.
C
      WRITE(1,2750)P1,P3
C
C     RESTORE N1
C
      N1=N9
      XLAB1(1)=9HFREQUENCY
      YLAB1(1)=3HPSD
      CALL HDCOPY
      CALL NEWPAG
      CALL INITT(300)
      CALL GPLOT(RAY,N3,XLAB,9,YLAB,3,2.,1.,10.,10.,2.,2.,IFLG,0.)
      CALL HDCOPY
      CALL CHRSIZ(3)
      GOTO 9999
C**********************************************************************
C**********************************************************************
 3200 PRINT(1,3300)
 3300 FORMAT(1X,"CUBIC INTERPOLATION TO HALVE SURVEY INTERVAL")
      I=4
      IO=I-3
      CO=1+INT((IO-1.)/256)
      RO=IO-256*(CO-1)
      I1=I-1
      C1=1+INT((I1-1.)/256)
      R1=I1-256*(C1-1)
      I2=I+1
      C2=1+INT((I2-1.)/256)
      R2=I2-256*(C2-1)
      YZ=A1(RO,CO)
      Y1=A1(R1,C1)
```

```
      Y2=A1(R2,C2)
      NN=N1-2
      DO 3500 I=4,NN,2
      I3=I+3
      C3=1+INT((I3-1.)/256)
      R3=I3-256*(C3-1)
      Y3=A1(R3,C3)
      CC1=Y1-YZ
      CC2=.5*(Y2-YZ)-CC1
      CC3=(Y3-YZ-3*CC1)/6-CC2
      C=1+INT((I-1.)/256)
      R=I-256*(C-1)
      A1(R,C)=YZ+1.5*CC1+.75*CC2-.375*CC3
      YZ=Y1
      Y1=Y2
      Y2=Y3
 3500 CONTINUE
      GOTO 1680
C*************************************************************************
C*************************************************************************
 3600 N1=2**ANS1+2*E
      GOTO 3900
 3610 PRINT(1,3620)
 3620 FORMAT(1X,"W.E.S. DIGITAL RECURSIVE FILTER",/)
      X1=A1(4,1)
      Y1=X1
      X2=A1(3,1)
      Y2=X2
      X3=A1(2,1)
      Y3=X3
      X4=A1(1,1)
      Y4=X4
      N6=N1+1
      DO 3700 I=5,N6
      CO=INT((I-1.)/256)+1
      RO=I-256*(CO-1)
      XO=A1(RO,CO)
      A1(RO,CO)=.5*(A1(RO,CO)-4*X1+6*X2-4*X3+X4)-(-3.871195*Y1+
     &5.619810*Y2-3.625898*Y3+.877285*Y4)
```

```
      WRITE(1,3640)X0,A1(R0,C0)
 3640 FORMAT(1X,F8.3,5X,F8.3)
      X4=X3
      X3=X2
      X2=X1
      X1=X0
      Y4=Y3
      Y3=Y2
      Y2=Y1
      Y1=A1(R0,C0)
 3700 CONTINUE
      N1=2**ANS1
      N6=N1+1
      DO3800 I=1,N6
      C0=INT((I-1.)/256)+1
      R0=I-256*(C0-1)
      J=I+E
      C1=INT((J-1.)/256)+1
      R1=J-256*(C1-1)
      A1(R0,C0)=A1(R1,C1)
      A2(R0,C0)=0.
 3800 CONTINUE
      ANS4=5
C*********************************************************************
C*********************************************************************
 3900 PRINT(1,3910)
 3910 FORMAT(///,1X,"FIRST TO LAST POINT DETRENDING",/)
      N1=2**ANS1
      IB=INT(N1/256.)+1
      IA=N1-256*(IB-1)
      X=(A1(IA,IB)-A1(1,1))/(N1-1)
      IF(N1.LT.2)GOTO 9999
      DO 4000 I0=2,N1
      C0=INT((I0-1.)/256)+1
      R0=I0-256*(C0-1)
      A1(R0,C0)=A1(R0,C0)-(I0-1)*X
 4000 CONTINUE
```

```
      AAZ=ANS4-2
      AZ=ABS(AAZ)
      IF(AZ.LT..1)GOTO 3610
      GOTO 1690
C*****************************************************************
C*****************************************************************
C     EXPONENTIALLY WEIGHTED RUNNING AVERAGE
C
 4050 PRINT(1,4060)
 4060 FORMAT(1X,"EXPONENTIALLY WEIGHTED RUNNING AVERAGE",//)
      L=30
      D=.5
      N1=2**ANS1+2*E
      IE=INT(E)
      DO 5000 I=1,IE
      KK(I)=EXP(-ANS2*I/L)
      D=D+KK(I)
 5000 CONTINUE
      D=D*2
      PRINT(1,5010)E,L
 5010 FORMAT(1X,4HE = ,F7.3,10X,4HL = ,I3,//)
      N8=IE+1
      N9=N1+1-IE
      DO 5120 L1=N8,N9
      C0=(INT((L1-1.)/256)+1)
      R0=L1-256*(C0-1)
      SU=A2(R0,C0)*1
      DO 5050 J=1,IE
      L2=J
      I0=L1+L2
      C1=(INT((I0-1.)/256)+1)
      R1=I0-256*(C1-1)
      S2=A2(R1,C1)
      I0=L1-L2
      C2=(INT((I0-1.)/256)+1)
      R2=I0-256*(C2-1)
      S3=A2(R2,C2)
      SU=SU+(S2+S3)*KK(J)
 5050 CONTINUE
```

```
      I1=L1-IE
      C1=1+INT((I1-1.)/256)
      R1=I1-256*(C1-1)
      A2(R1,C1)=0
      A1(R1,C1)=A2(R0,C0)-(SU/D)
      WRITE(1,5110)L1,A2(R0,C0),A1(R1,C1)
 5110 FORMAT(1X,I3,6X,F10.6,6X,F10.6)
 5120 CONTINUE
      N1=2**ANS1
C
C     NOW DO 1ST TO LAST POINT DE-TRENDING
C
      GOTO 3900
C***********************************************************************
C***********************************************************************
 9999 STOP
      END
```

INDEX OF VARIABLES FOR SIGNAL ANALYSIS PROGRAM
(VARIABLE NAME AND PROGRAM LINE NUMBERS)

A	4830, 5090, 5370, 5400, 5420, 5490, 5890, 6000, 6030, 6060, 6110
AAZ	7260, 7270
AZ	7260, 7270, 7280
ANS1	180, 320, 330, 340, 350, 360, 370, 860, 960, 1410, 1420, 1860, 1870, 3550, 3610, 3720, 4130, 4230, 5330, 6700, 7000, 7160, 7380, 7730
ANS2	410, 420, 430, 870, 970, 990, 1200, 1880 4960, 5130, 5550, 6030, 6080, 6150, 7410
ANS3	180, 470, 480, 490, 880, 1040, 1050, 1070
ANS4	180, 540, 550, 560, 890, 1010, 1100, 1630, 2110, 7110, 7260
ANS5	180, 600, 610, 620, 900, 1140, 1400
ANS6	180, 660, 670, 680, 910, 1470, 2060
ANS7	180, 720, 730, 740, 920
ANS8	180, 780, 790, 800, 930, 5780
A1(,)	130, 1190, 1290, 1310, 1680, 1840, 1920, 2020, 2230, 2330, 2360, 2370, 2380, 2390, 2620, 2640, 2710, 2760, 3080, 3090, 3930, 3940, 3980, 4000, 4030, 4060, 4390, 4400, 4410, 4480, 4580, 4640, 4680, 4700, 4890, 5040, 5050, 5170, 5990, 6480, 6490, 6500, 6560, 6620, 6740, 6760, 6780, 6800, 6860, 6870, 6890, 6980, 7080, 7190, 7240, 7690, 7700

A2(,)	130, 1310, 1690, 3090, 3930, 3940, 3990, 4010, 4030, 4060, 4420, 4430, 4440, 4490, 4590, 4600, 4650, 4660, 4670, 4690, 4710, 5040, 5050, 6000, 7090, 7520, 7580, 7620, 7680, 7690, 7700
B	6000, 6020
B1	2380, 2400, 2490, 2510, 2540, 2630, 2750
B2	2390, 2400, 2630, 2640, 2690, 2700, 2740, 2750, 2760, 2780, 2790, 2820
B3	2630, 2650
B4	2640, 2650
C	6610, 6620, 6630
CC1	6580, 6590, 6600
CC2	6590, 6600, 6630
CC3	6600, 6630
CO	190, 1160 1170, 1180, 1220, 1230, 1290, 1310, 1660, 1670, 1680, 1690, 1790, 1800, 1840, 2280, 2290, 2330, 2600, 2610, 2620, 2640, 2710, 2760, 3010, 3020, 3080, 3090, 5970, 5980, 5990, 6000, 6400, 6410, 6480, 6840, 6850, 6860, 6870, 6890, 6980, 7030, 7040, 7080, 7090, 7220, 7230, 7240, 7500, 7510, 7520, 7690, 7700
CZ	4530, 4590, 4610, 4630, 4650, 4670

C1	190, 1820, 1830, 1840, 1940, 1950, 2020, 3040, 3050, 3090, 4460, 4470, 4480, 4490, 4540, 4550, 4580, 4590, 4600, 4610, 4640, 4650, 4660, 4680, 4690, 6430, 6440, 6490, 7060, 7070, 7080, 7560, 7570, 7580, 7660, 7670, 7680, 7690, 7700
C2	190, 1970, 1980, 2020, 3060, 3070, 3080, 4560, 4570, 4580, 4590, 4600, 4610, 4640, 4650, 4660, 4670, 4700, 4710, 6470, 6480, 6510, 7610, 7620, 7630
C3	190, 2000, 2010, 2020, 6540, 6550, 6560
D	7380, 7430, 7450, 7700
E	970, 980, 1020
F	4860, 4970, 5200, 5280, 5300, 5380, 5400, 5420, 5440, 6100, 6110, 6120
F1	4820, 5200, 5280, 5480
G	5130, 5170, 5180, 5190, 5310, 5320, 5400, 5420, 5450, 6040, 6050, 6110, 6130, 6140
GO()	5990, 6000
I	1120, 1190, 1210, 1780, 1790, 1800, 1810, 2960, 3010, 3020, 3030, 3340, 3410, 3420, 3430, 3440, 3450, 3520, 3720, 3840, 3850, 3860, 3950, 3960, 3970, 4030, 4060, 4230, 4910, 4950, 4960, 5010, 5020, 5260, 5330, 5340, 5360, 5370, 5380, 5390, 5440, 5450, 5500, 5870, 5910, 6070, 6080, 6110, 6120, 6380, 6390, 6420, 6450, 6520, 6530, 6600, 6610, 6830, 6840, 6850, 7020, 7030, 7040, 7050, 7400, 7410, 7420

IA	7180, 7190
IB	7170, 7180, 7190
IE	980, 1640, 7400, 7410, 7480, 7490, 7540, 7660
IO	1610, 1620, 1640, 2270, 2280, 2290, 2480, 2490, 2510, 2530, 2550, 2590, 2600, 2610, 2690, 2700, 2720, 2730, 6390, 6400, 6410, 7210, 7220, 7230, 7240, 7550, 7560, 7570, 7590, 7600, 7610
IO1	2550, 2720, 2730, 2740, 2800, 2810, 2820, 2880
I1	270, 1120, 1210, 1620, 1640, 1650, 1660, 1670, 1930, 1940, 1950, 3860, 3870, 3880, 3970, 3980, 3990, 4000, 4010, 4030, 4060, 5020, 5040, 5050, 5170, 6430, 6440, 6450, 7660, 7670, 7680
I2	270, 1150, 1160, 1170, 1210, 1220, 1230, 1960, 1970, 1980, 3030, 3040, 3050, 3060, 3070, 3850, 3860, 3870, 3880, 3960, 3970, 3980, 3990, 4000, 4010, 4030, 4060, 5010, 5020, 5040, 5050, 5170, 6460, 6470
I3	1990, 2000, 2010, 6540, 6550, 6560
J	270, 1810, 1820, 1830, 3430, 3460, 3490, 3520, 3900, 3910, 3920, 4030, 4060, 4180, 4190, 4370, 4380, 5920, 5930, 5940, 5960, 5970, 5980, 5990, 7060, 7070, 7080, 7540, 7550, 7640
JB	1540, 1550, 1580, 1680, 1690, 1710

JG	1550, 1590, 1680, 1690, 1700, 1710, 1720
J1	270, 3450, 3460, 3470, 3920, 3930, 3940, 3980, 3990, 4030, 4060, 4380, 4390, 4400, 4420, 4430
J2	3910, 3920, 3930, 3940, 3980, 3990, 4060, 4370, 4380, 4390, 4400, 4420, 4430
J6	4360, 4400, 4410, 4430, 4440
J7	4350, 4360, 4400, 4410, 4430, 4440
J8	4340, 4350, 4360
K	140, 200, 270, 1650, 1770, 2200, 3420, 3430, 3440, 3450, 3460, 3470, 3520, 3620, 3660, 3670, 3680, 3730, 3740, 3750, 3760, 3770, 3800, 3830, 3840, 3870, 3880, 3900, 3930, 3940, 3950, 3980, 3990, 4000, 4010, 4090, 4190, 4200, 4210, 4220, 4240, 4250, 4260, 4270, 4280, 4300, 4340, 4500, 4510, 4520, 4530, 4540, 4550, 4810, 5210, 5280, 5470, 5910, 5920, 6000, 6010, 7420, 7640
KK	140, 200, 7420, 7430, 7640
K1	270, 3440, 3450, 3460, 3470, 3660, 3730, 3740, 3770, 4200, 4240, 4250, 4280
K2	3730, 3740, 3770, 4240, 4250, 4280
K8	3670, 3750, 3840, 4210, 4260, 4300, 4340

K9	200, 3680, 3750, 3760, 4220, 4260, 4270
K22()	140, 200, 3870, 3880, 3930, 3940
K33()	140, 200, 3930, 3940, 3980, 3990, 4000, 4010
L	3540, 3580, 3610, 4110, 4120, 4130, 7360, 7420, 7460
L1	7500, 7510, 7520, 7560, 7600, 7660, 7710
L2	7550, 7560, 7600
M	3560, 4100, 4110, 4510, 4560, 4570, 4620, 4630
N	3180, 3190, 4520, 4530, 4620, 4630, 4960, 5090, 5510, 5220, 5260, 5500, 5550, 6060, 6090, 6160
NN	6510, 6520
NZ	1110, 1120, 1600, 1610
N1	590, 1020, 1110, 1150, 1420, 1600, 1770, 1780, 1870, 1930, 1960, 1990, 2270, 2350, 2590, 2780, 2790, 2810, 2900, 2950, 3180, 3210, 3230, 3400, 3890, 3900, 3950, 4070, 4080, 6230, 6250, 6520, 6710, 6830, 7010, 7020, 7170, 7180, 7190, 7200, 7210, 7220, 7390, 7490, 7740
N2	2950, 2960, 3190, 3320, 3330, 4180, 4460, 4470, 4510, 4730

N3	4730, 4910, 5670, 5870, 5930, 5950, 5960, 6300
N4	3400, 3410, 3680, 4220, 4500
N6	6820, 6830, 7010, 7020
N8	7480, 7500
N9	3230, 6250, 7490, 7500
P	4850, 4960, 4970, 5300, 5330, 5350, 5360, 5400, 5420, 6060, 6090, 6100, 6110
PI	280, 1200, 1280, 1290, 1350, 1360, 3320, 3330, 4520, 4530, 4620, 4630
PZ	4840, 4850, 5260, 5500
P1	4600, 5180, 5550, 5560, 5590, 5830, 6140, 6160, 6170, 6210
P2	190, 3610, 3840, 3900, 4080, 4090
P3	5550, 5560, 5590, 6150, 6160, 6200
P4	4870, 5190, 5310, 5460
R	6620, 6630
RO	190, 1180, 1230, 1290, 1310, 1670, 1680, 1690, 1800, 1840, 2290, 2330, 2610, 2620, 2640, 2710, 2760, 3020, 3080, 3090, 5980, 5990, 6000, 6410, 6480, 6850, 6860, 6870, 6890, 6980, 7040, 7080, 7090, 7230, 7240, 7510, 7520, 7690, 7700

RAY(,)	150, 5380, 5390, 5440, 5450, 5730, 6110, 6120, 6310
RAY1(,)	160, 2530, 2540, 2730, 2740, 2810, 2820, 2890
RAY2(,)	170, 5330, 5340, 5360, 5370, 5670
R1	190, 1830, 1840, 1950, 2020, 3050, 3090, 4470, 4480, 4490, 4550, 4580, 4590, 4600, 4610, 4640, 4650, 4660, 4670, 4680, 4690, 6450, 6500, 7080, 7090, 7570, 7580, 7670, 7680, 7690, 7700
R2	190, 1980, 2020, 3070, 4570, 4580, 4590, 4600, 4610, 4640, 4650, 4660, 4670, 4700, 4710, 6470, 6500, 7610, 7620
R3	190, 2010, 2020, 6550, 6560
ST	2230, 2310, 2330, 2350
SU	7530, 7640, 7700
SZ	4520, 4580, 4600, 4620, 4640, 4660
S2	7640
S3	7630, 7640
T2	1200, 1280, 1290, 1300, 1350, 1360
W1(,)	130, 3270, 3320, 3360, 3460, 3470, 3490, 3520, 3870
W2(,)	130, 3280, 3330, 3360, 3460, 3470, 3490, 3520, 3880

X	1190, 1200, 2400, 2710, 2900, 2910, 2920, 4390, 4410, 4420, 4440, 5050, 5130, 5870, 6030, 6040, 6060, 6260, 7190, 7250
XLAB()	150, 5700, 5740, 6300
XLAB1()	160, 2830, 2880, 6250
XLAB2()	170, 5640, 5670
XO	6860, 6890, 6940
XX(,)	140, 210, 1550, 1680, 1690
X1	6740, 6750, 6870, 6930, 6940
X2	6760, 6770, 6870, 6920, 6930
X3	6780, 6790, 6870, 6910, 6920
X4	6800, 6810, 6870, 6910
Y	1350, 2350, 2360, 2370, 2420, 2620
YLAB()	150, 5710, 5740, 6310
YLAB1()	160, 2840, 2880, 6260
YLAB2()	170, 5650, 5670
YZ	6480, 6570, 6580, 6590, 6620, 6630
Y1	6490, 6570, 6630, 6640, 6750, 6870, 6980
Y2	6500, 6580, 6640, 6650, 6770, 6880, 6960, 6970

Y3	6560, 6590, 6650, 6790, 6880, 6950, 6960
Y4	6810, 6880, 6950
Z1	4580, 4680
Z2	4600, 4690
Z3	4640, 4700
Z4	4660, 4710

GLOSSARY OF VARIABLES
FOR
SIGNAL ANALYSIS PROGRAM
(VARIABLE NAME AND DESCRIPTION)

VARIABLE	DESCRIPTION
A	Amplitude
ANS1	The number of terrain points is equal to 2^{ANS1} where $1 \leq ANS1 \leq 8$.
ANS2	The length of the survey interval in feet, ANS2 allows 4 places to the right of the decimal point.
ANS3	The code for type of input data is as follows: 0 for data equations 1 for card reading -1 for data equations
ANS4	The code for type of detrending is as follows: 1 for first to last point detrending 2 for digital high pas filter 3 for exponentially weighted 4 for no detrending
ANS5	The code for padding the array with N1 0's is: 1 for yes 2 for no
ANS6	The code for interpolation is: 1 for yes 2 for no
ANS7	The code for amplitude smoothing is: 1 for yes 2 for no

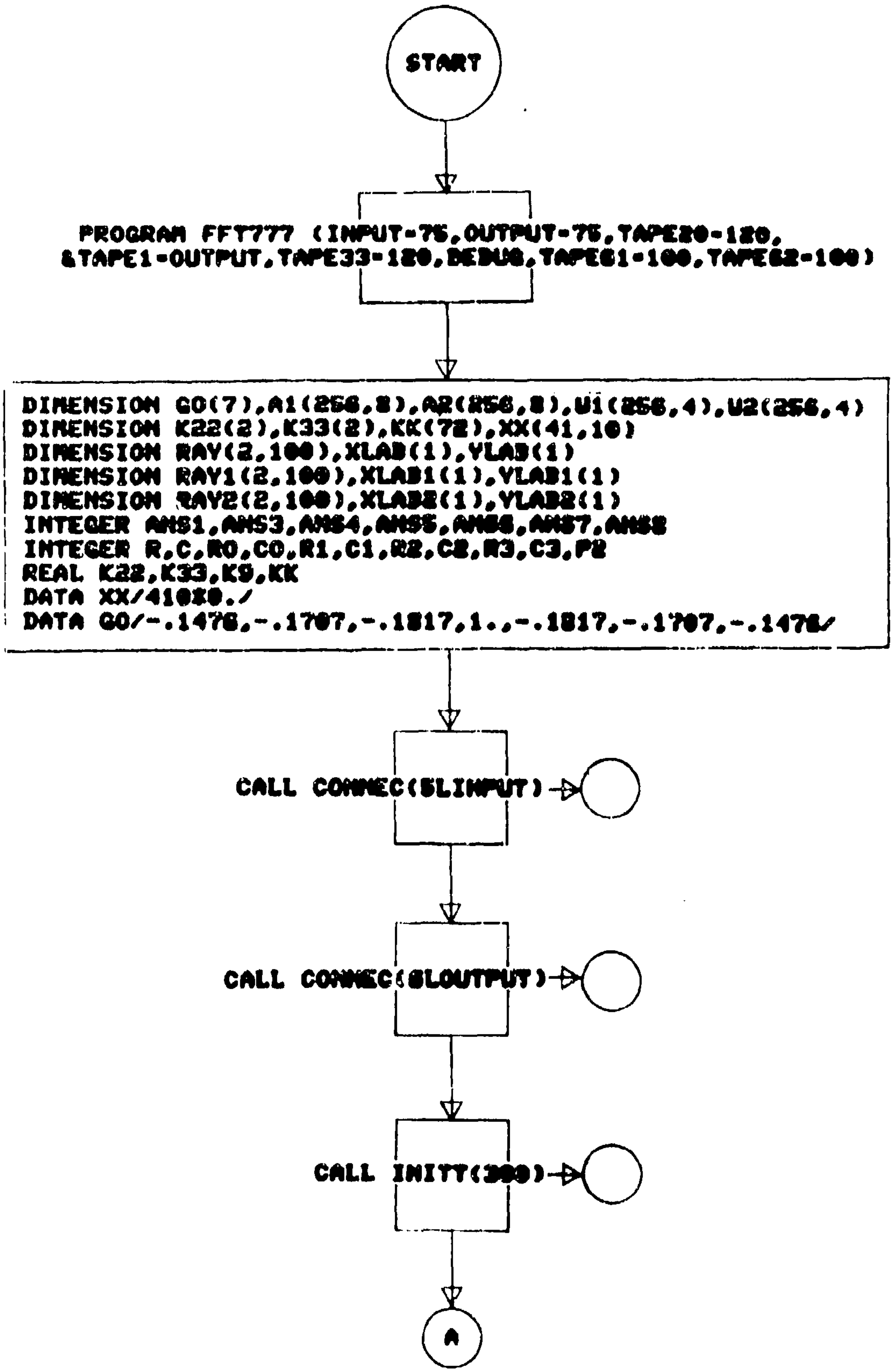
VARIABLE	DESCRIPTION
ANS8	The code for GEO window is: 1 for yes 2 for no
A1(,)	Storage array for terrain evaluation data.
A2(,)	Storage array for terrain evaluation data.
B1	Relative maximum and minimum profile values.
B2	Relative maximum and minimum profile values.
C	The ordinate of the point A1(R,C).
CO	The ordinate of the point A1(RO,CO).
C1	The ordinate of the point A1(R1,C1).
C2	The ordinate of the point A2(R2,C2).
C3	The ordinate of the point A1(R3,C3).
E	The quantity 36 divided by the length of the survey interval in feet.
F	Frequency.
F1	The summation of the frequencies.
G	Power spectral density.
GO()	The coefficients of the GEO window.
IA	The abscissa of the point A1(IA,IB)
IB	The ordinate of the point A1(IA,IB)

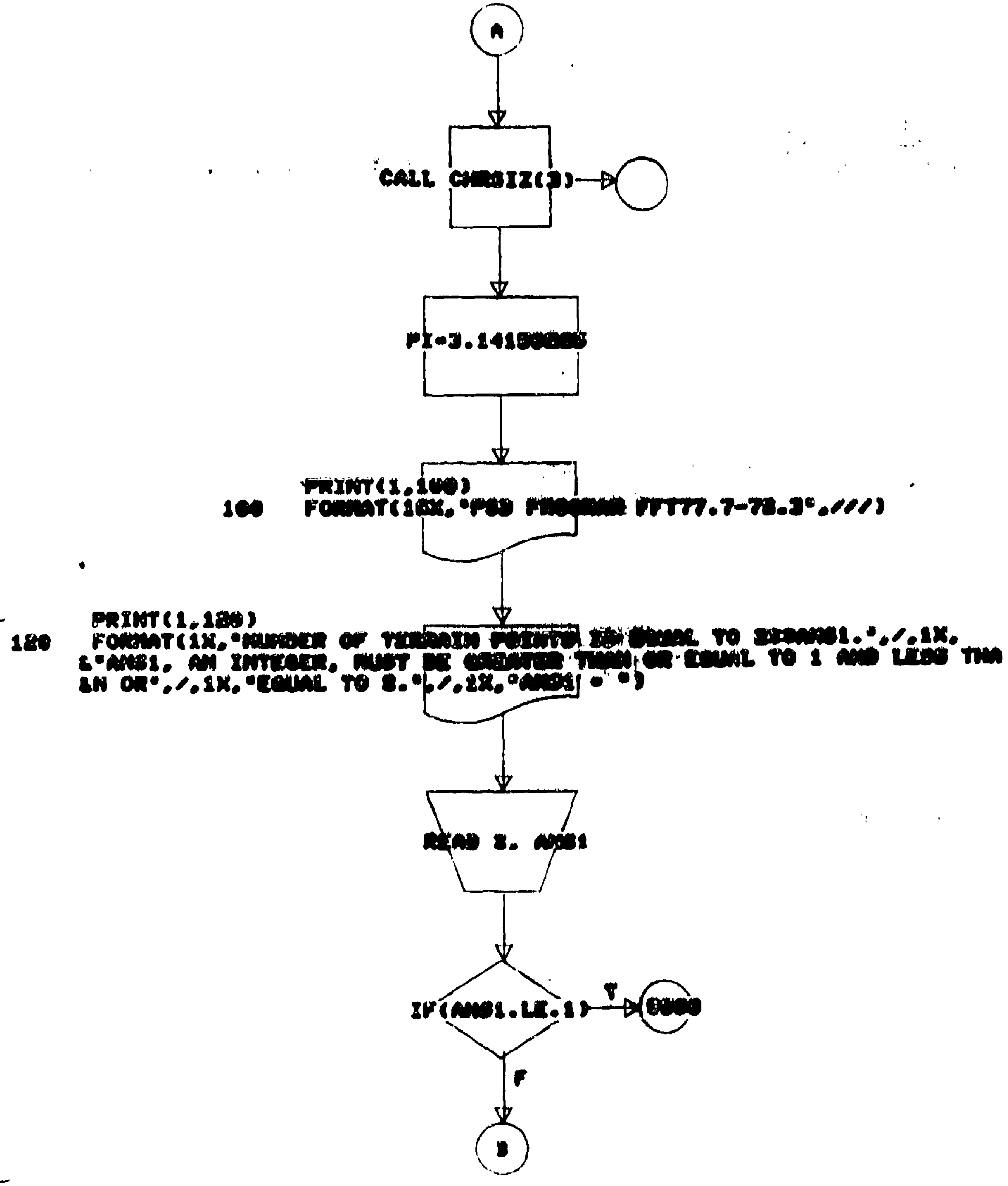
VARAIBLE	DESCRIPTION
J	The abscissa of the point W1(J,K).
JB	The abscissa of the point XX(JB,JG).
JG	The ordinate of the point XX(JB,JG).
J1	The abscissa of the point W1(J1,K1) and of A1(J1,J2).
J6	The abscissa of the point A2(J6,J7).
J7	The ordinate of the point A2(J6,J7)
K	The ordinate of the point W1(J,K)
K1	The ordinate of the point W1(J1,K1).
N1	Number of terrain points.
N2	Number of terrain points divided by 2.
P	period
PI	3.14159265
PZ	9999.99
P1	Root mean square.
P3	Area under psd.
P4	The summation of the power spectral densities.
R	The abscissa of the point A1(R,C).
RO	The abscissa of the point A1(RO,CO).

VARIABLE	DESCRIPTION
RAY(,)	Storage array for frequencies and psd's.
RAY1(,)	Storage array for terrain points and maximum and minimum profile values.
RAY2(,)	Storage array for periods and amplitudes.
R1	The abscissa of the point A2(R1,C1).
R2	The abscissa of the point A2(R2,C2).
R3	The abscissa of the point A1(R3,C3).
ST	The summation of the values of the terrain point.
W1(,)	Stored values of $(e^{-j})^{2\pi/N}$
W2(,)	Stored values of $(e^{-j})^{2\pi/N}$
X	RMS from detrended zero mean terrain data.
XLAB()	Storage for disruption "FREQUENCY" of x - axis used in graphics display.
XLAB1()	Storage for disruption "DISTANCE" of x - axis used in graphics display.
XLAB2()	Storage for disruption "PERIOD" of x - axis used in graphics display.
XX(,)	Terrain profile data array.
Y	The value of the data equation; the average terrain point value.
YLAB()	Storage for disruption "PSD" of y - axis used in graphics display.

VARIABLE	DESCRIPTION
YLAB2()	Storage for disruption "AMPLITUDE" of y - axis used in graphics display.

FLOWCHART FOR SIGNAL ANALYSIS PROGRAM





A
CALL CHRSIZ(3)
PRINT(1,100)
100 FORMAT(10X,"PSD PROGRAM FFT77.7-78.3",///)
PRINT(1,120)
120 FORMAT(1X,"NUMBER OF TERRAIN POINTS IS EQUAL TO 2**ANS1.",/,1X,
&"ANS1, AN INTEGER, MUST BE GREATER THAN OR EQUAL TO 1 AND LESS THA
&N OR",/,1X,"EQUAL TO 8.",/,1X,"ANS1 = ")
IF(ANS1.LE.1)
T
F
B

D

```
      PRINT(1,170)
170   FORMAT(1X,"SURVEY INTERVAL IN FEET? ALLOW 4 PLACES PAST DECIMAL."
     &,/,1X,"ANS2 = ")
```

READ *,ANS2

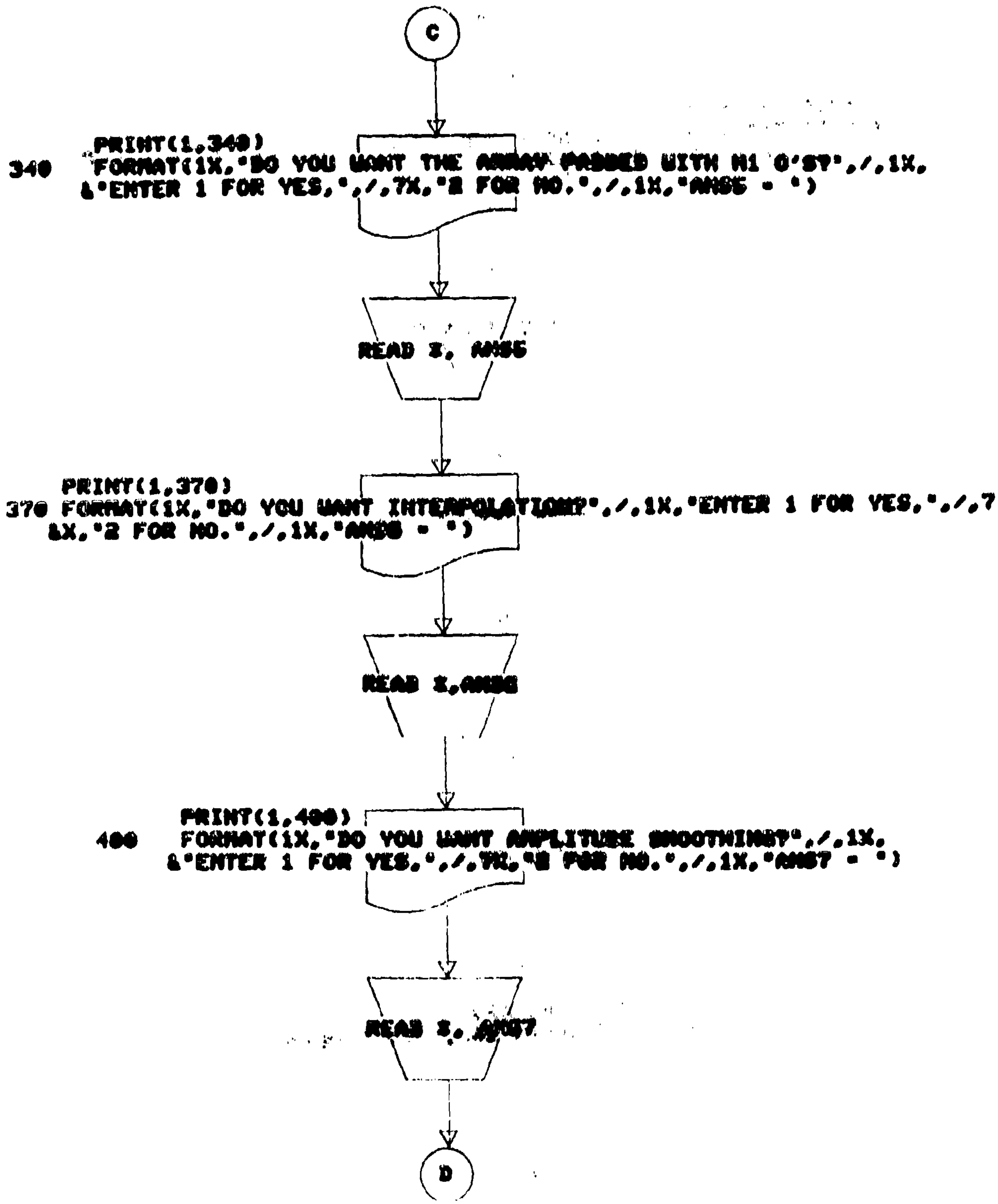
```
      PRINT(1,200)
200   FORMAT(1X,"ENTER 0 FOR DATA READING,",/,7X,"1 FOR CARD READING,",
     &/,6X,"-1 FOR DATA EQUATIONS.",/,1X,"ANS3 = ")
```

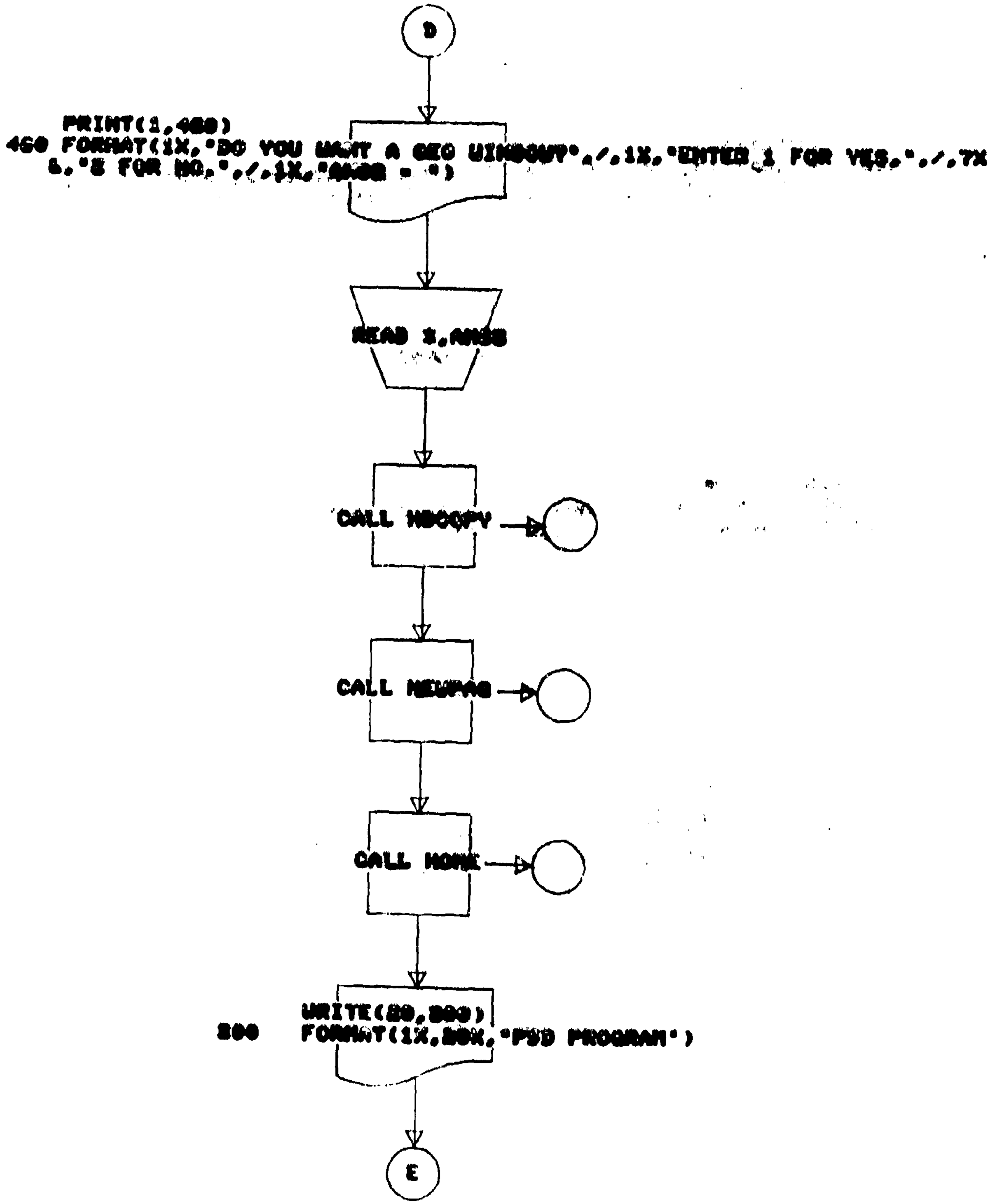
READ *, ANS3

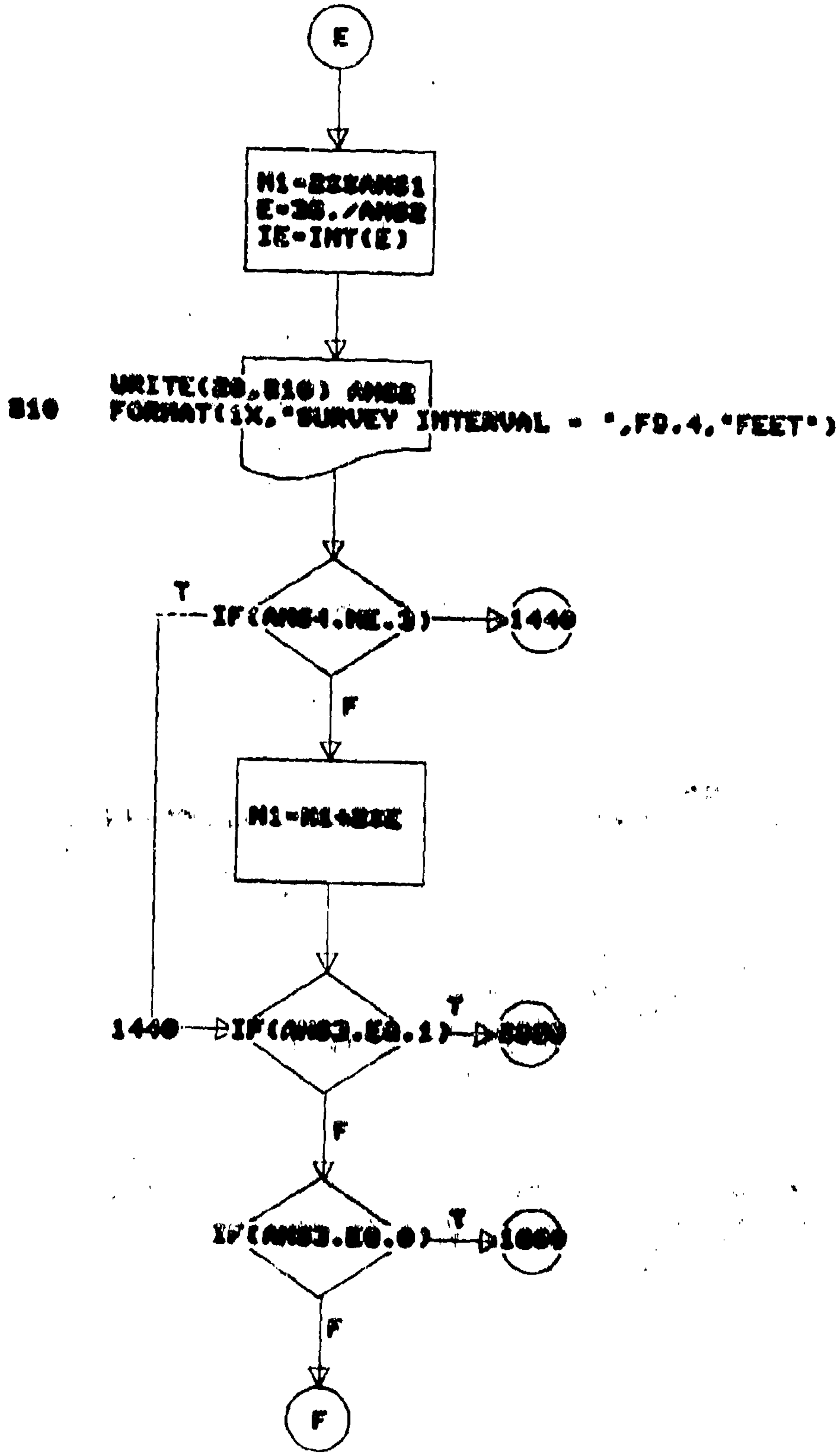
```
     PRINT(1,220)
220  FORMAT(1X,"ENTER 1 FOR FIRST TO LAST POINT DETRENDING,",/,7X,"2 FO
    &R DIGITAL HIGH PASS FILTER,",/,7X,"3 FOR EXPONENTIALLY WEIGHTED RU
    &NNING AVERAGE,",/,7X,"4 FOR NO DETRENDING.",/,1X,"ANS4 = ")
```

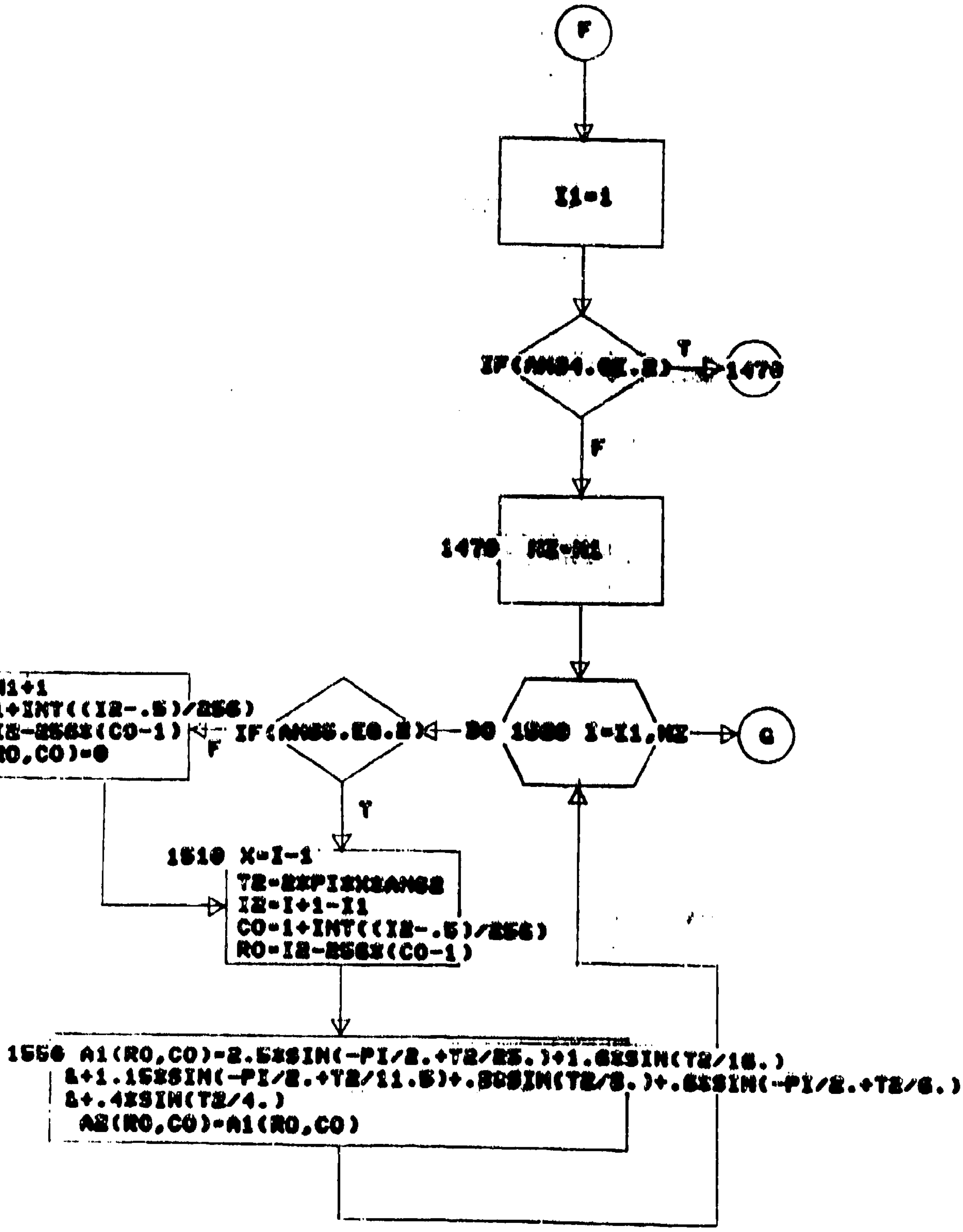
READ *,ANS4

C

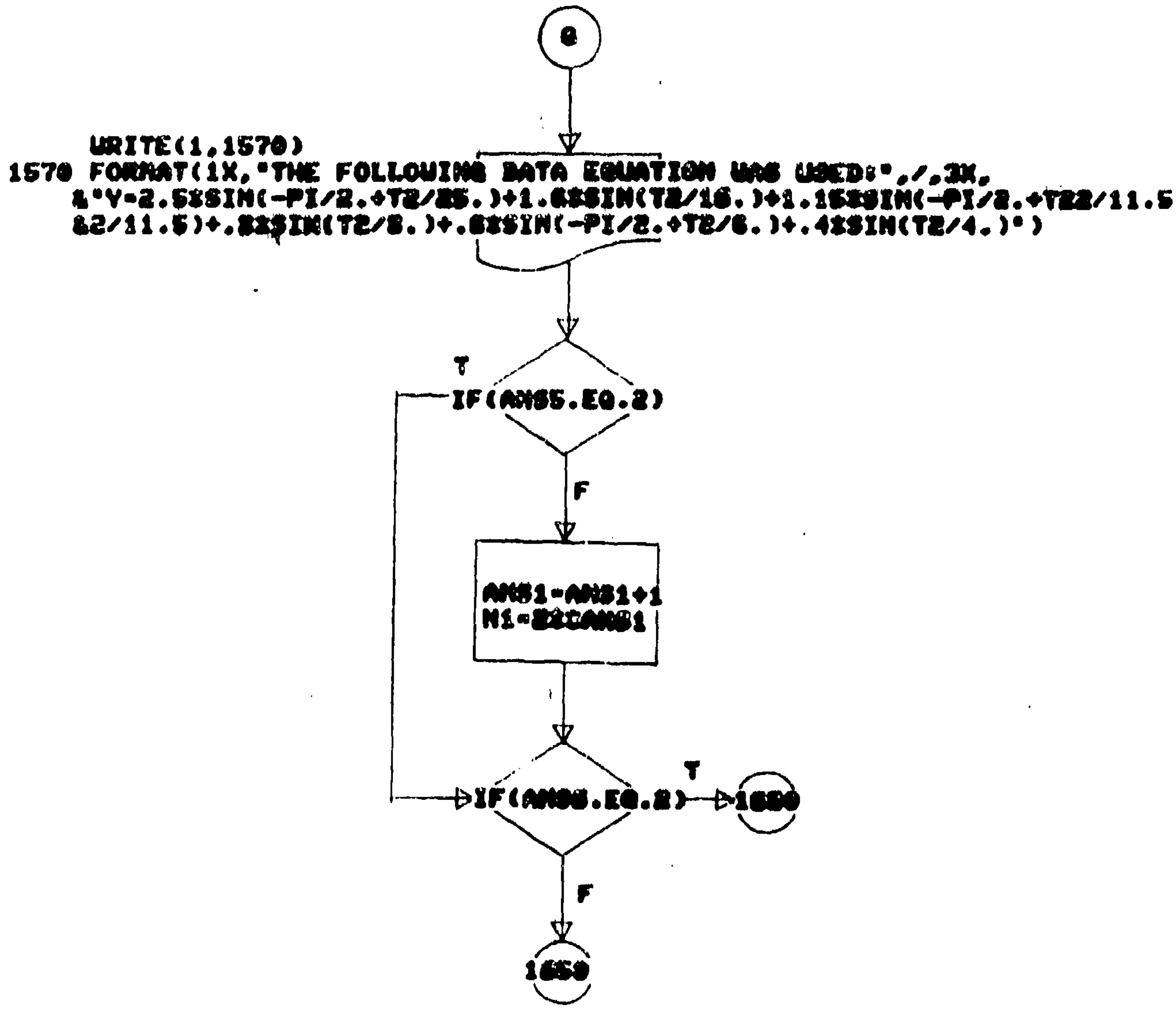

C
PRINT(1,340)
340 FORMAT(1X,'DO YOU WANT THE ARRAY PADDED WITH N1 0'S?',/,1X,
&'ENTER 1 FOR YES,',/,7X,'2 FOR NO.',/,1X,'ANS5 = ')
READ *, ANS5
PRINT(1,370)
370 FORMAT(1X,'DO YOU WANT INTERPOLATION?',/,1X,'ENTER 1 FOR YES,',/,7
&X,'2 FOR NO.',/,1X,'ANS6 = ')
READ *,ANS6
PRINT(1,400)
400 FORMAT(1X,'DO YOU WANT AMPLITUDE SMOOTHING?',/,1X,
&'ENTER 1 FOR YES,',/,7X,'2 FOR NO.',/,1X,'ANS7 = ')
READ *, ANS7
D


D
PRINT(1,460)
460 FORMAT(1X,'DO YOU WANT A GEO WINDOUT',/,1X,'ENTER 1 FOR YES,',/,7X
&,'2 FOR NO,',/,1X,'ANSR = ')
READ 1,ANSR
CALL HDCOPY
CALL NEWPAG
CALL HOME
WRITE(20,800)
800 FORMAT(1X,30X,'PSD PROGRAM')
E

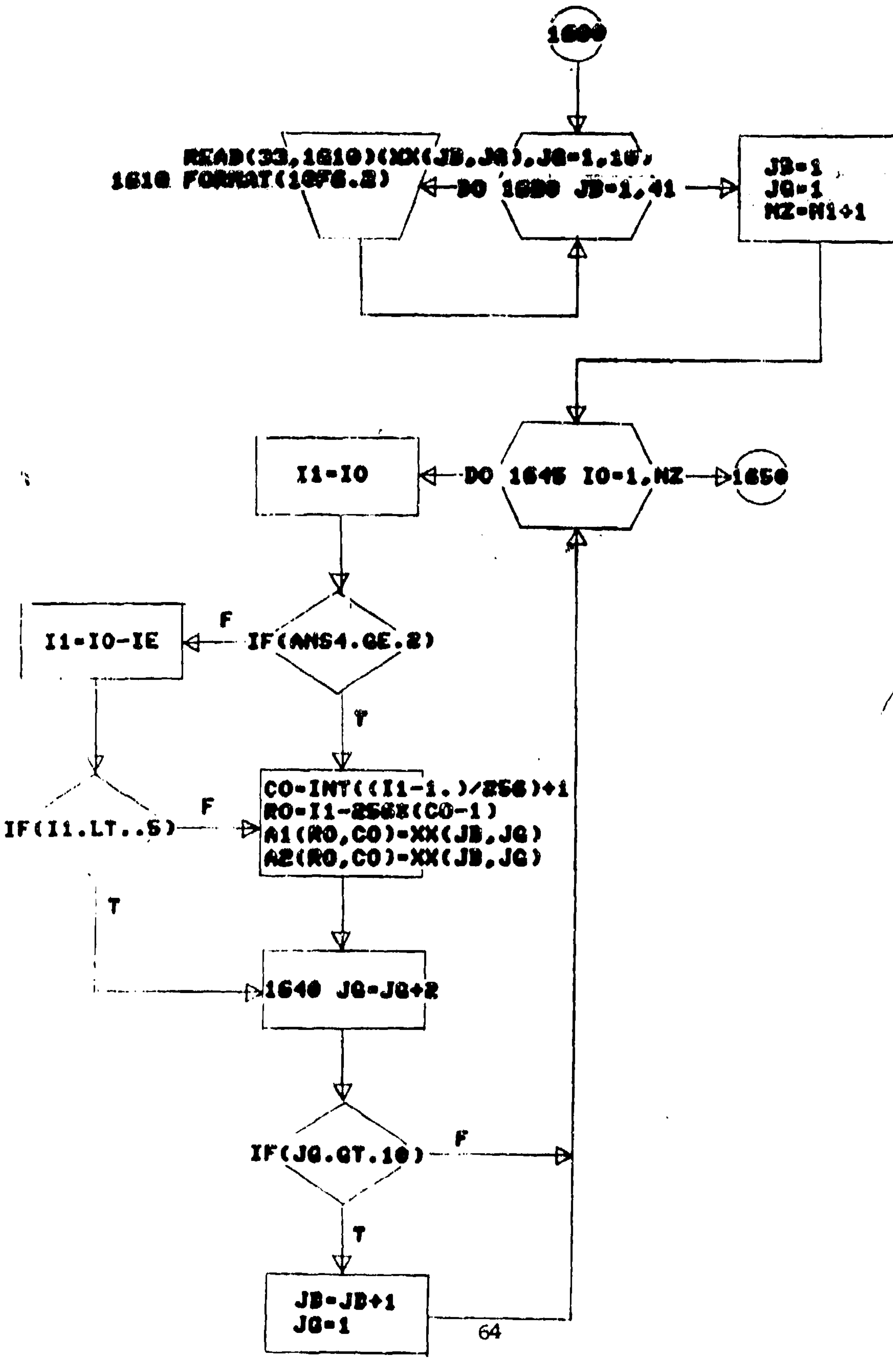

E
IE=INT(E)
810
FORMAT(1X,"SURVEY INTERVAL = ",F9.4,"FEET")
T
1440
F
1440
T
F
T
F
F

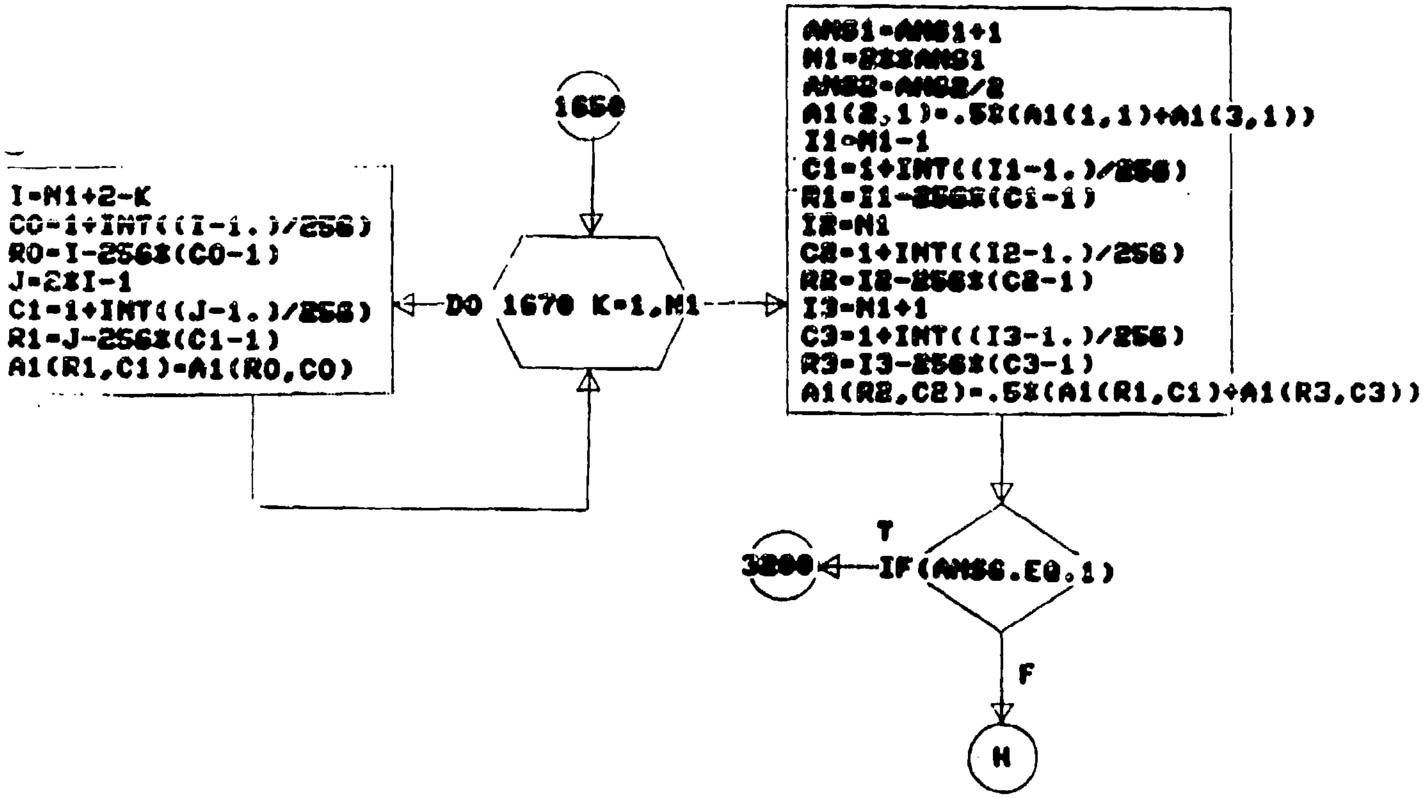


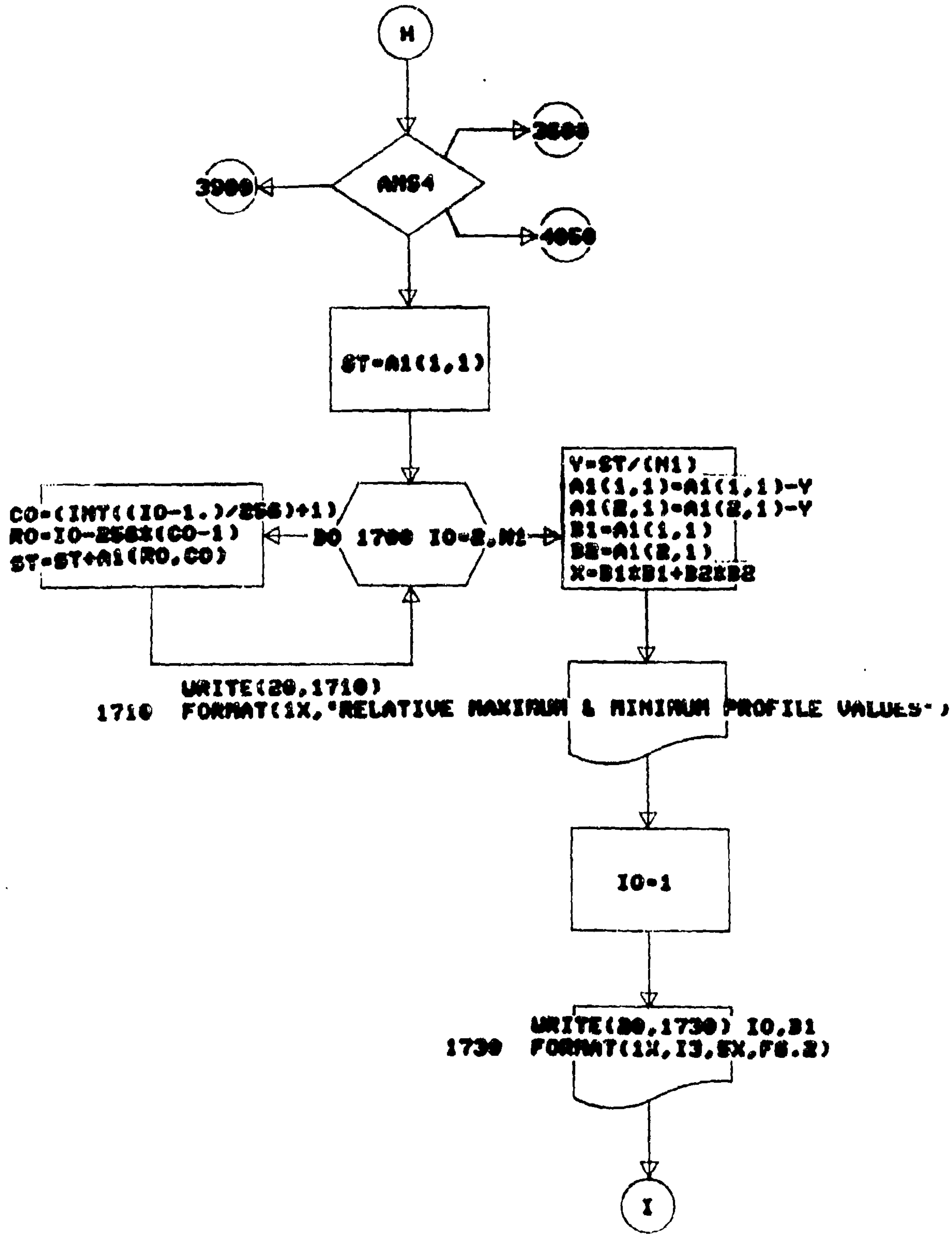
F
I1=1
T
1470
F
1470
I2=N1+1
CO=1+INT((I2-.5)/256)
RO=I2-256*(CO-1)
A1(RO,CO)=0
F
G
T
1510 X=I-1
I2=I+1-I1
CO=1+INT((I2-.5)/256)
RO=I2-256*(CO-1)
A1(RO,CO)=2.5*SIN(-PI/2.+T2/25.)+1.6*SIN(T2/16.)
&+1.15*SIN(-PI/2.+T2/11.5)+.8*SIN(T2/8.)+.6*SIN(-PI/2.+T2/6.)
&+.4*SIN(T2/4.)
A2(RO,CO)=A1(RO,CO)

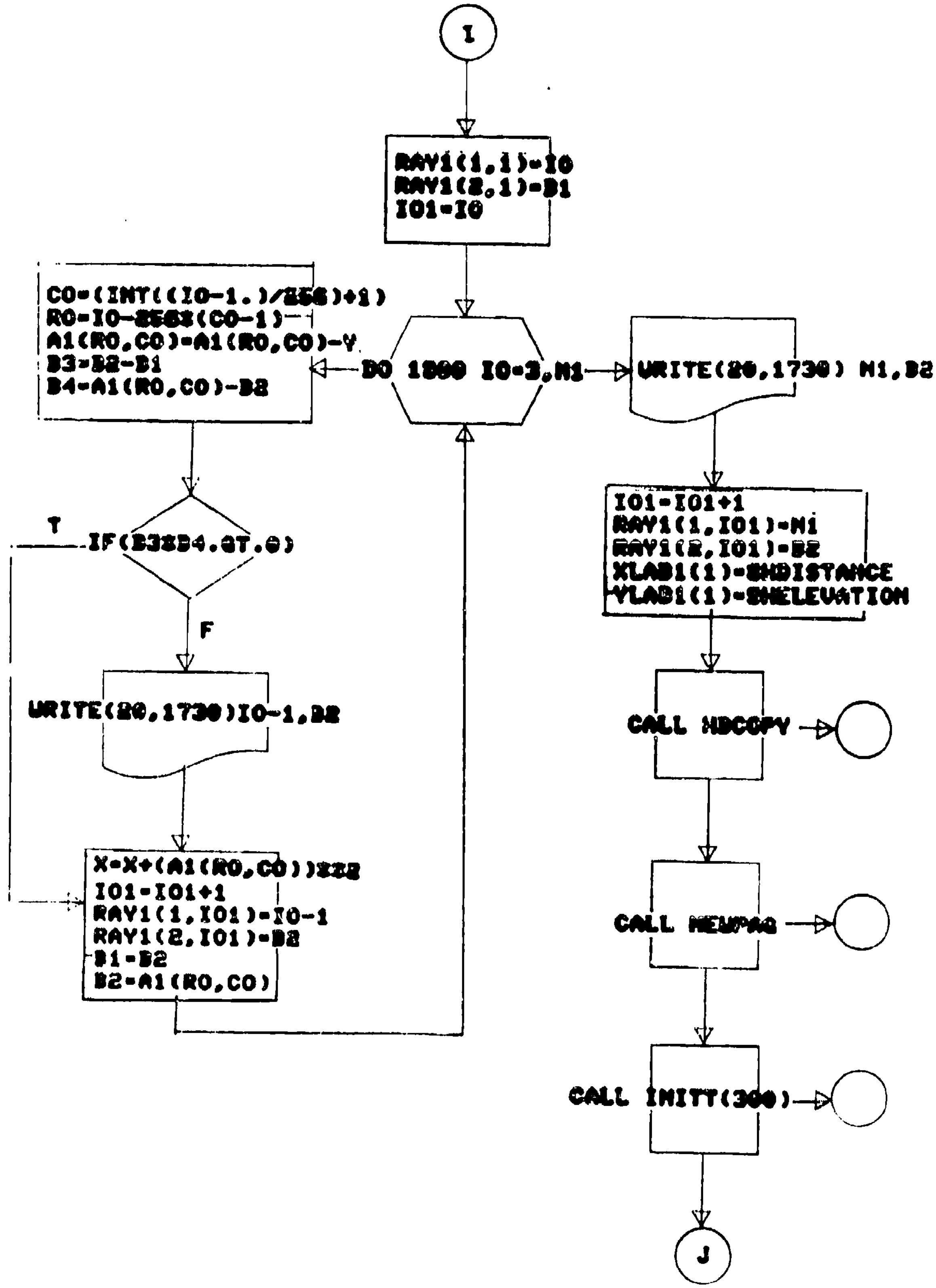


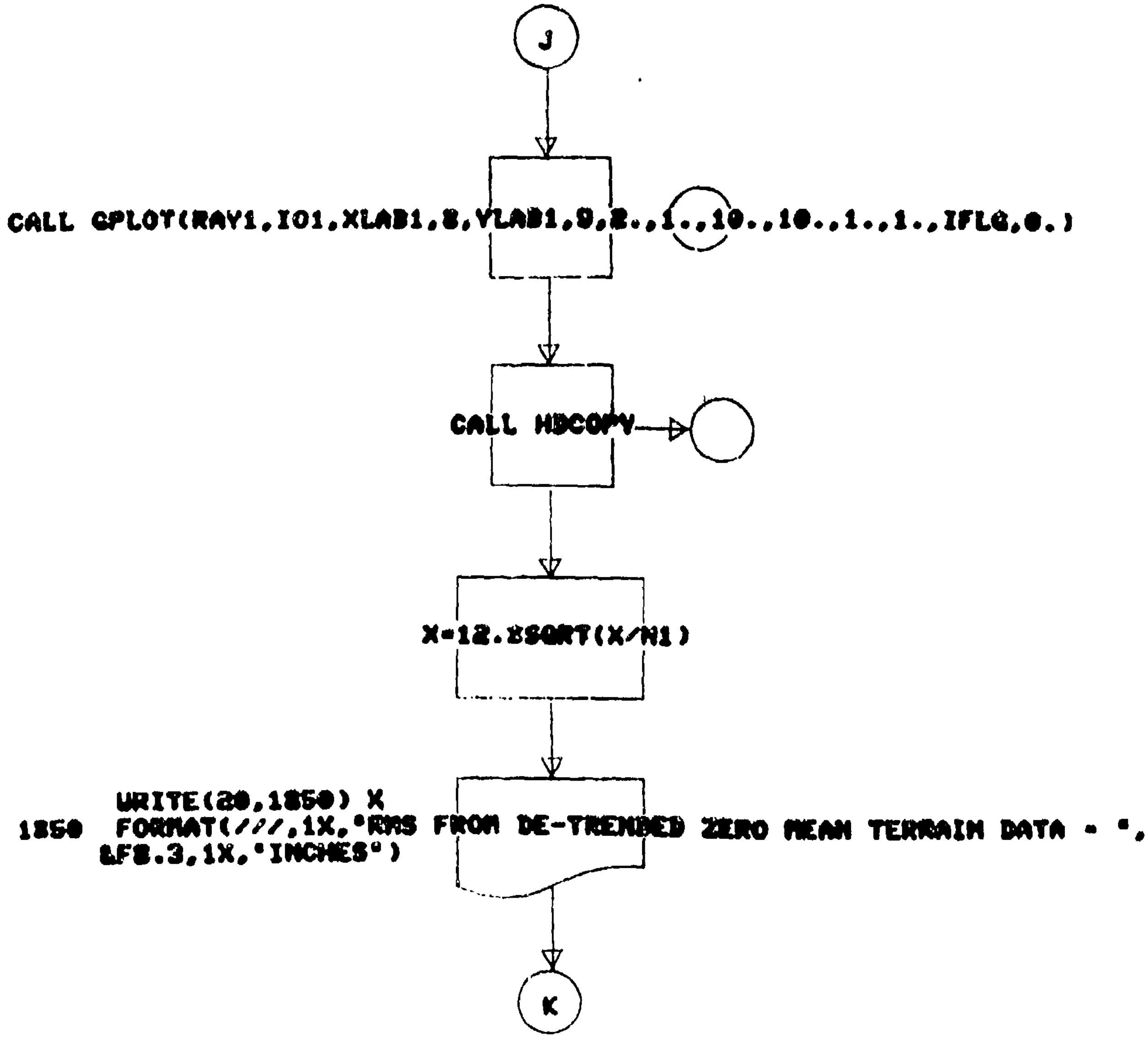
WRITE(1,1570)
1570 FORMAT(1X,"THE FOLLOWING DATA EQUATION WAS USED:",/,3X,
&"Y=2.5*SIN(-PI/2.+T2/25.)+1.6*SIN(T2/16.)+1.15*SIN(-PI/2.+T2*2/11.5
&2/11.5)+.8*SIN(T2/8.)+.6*SIN(-PI/2.+T2/6.)+.4*SIN(T2/4.)")
T
IF(ANS5.EQ.2)
F
ANS1=ANS1+1
T
F
1650

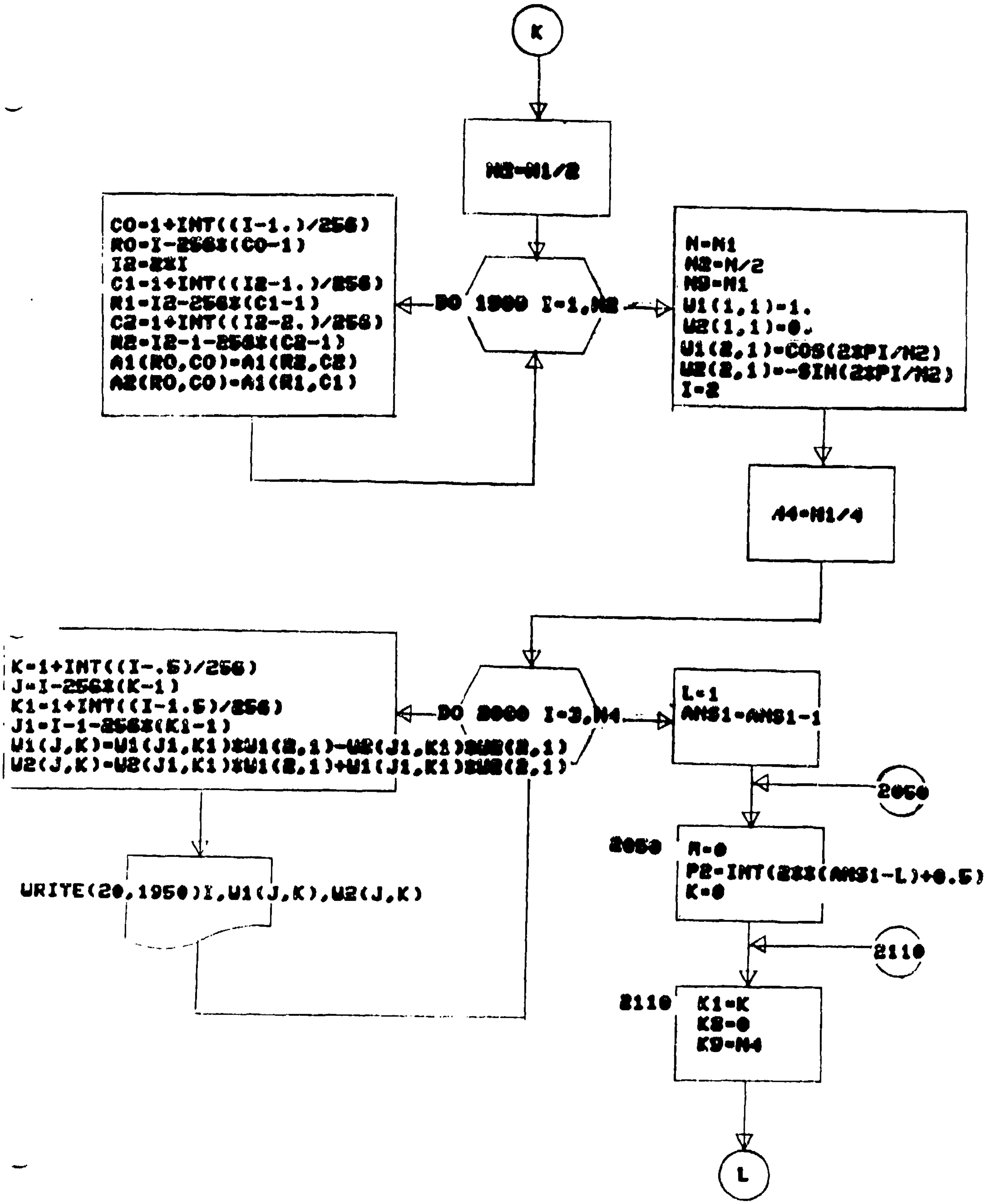

1600
READ(33,1610)(XX(JB,JG),JG=1,16)
1610 FORMAT(16F6.2)
DO 1600 JB=1,41
JB=1
JG=1
NZ=N1+1
DO 1645 IO=1,NZ
1650
I1=IO
IF(ANS4.GE.2)
F
T
I1=IO-IE
IF(I1.LT..5)
F
T
CO=INT((I1-1.)/256)+1
RO=I1-256*(CO-1)
A1(RO,CO)=XX(JB,JG)
A2(RO,CO)=XX(JB,JG)
1640 JG=JG+2
IF(JG.GT.16)
F
T
JB=JB+1
JG=1

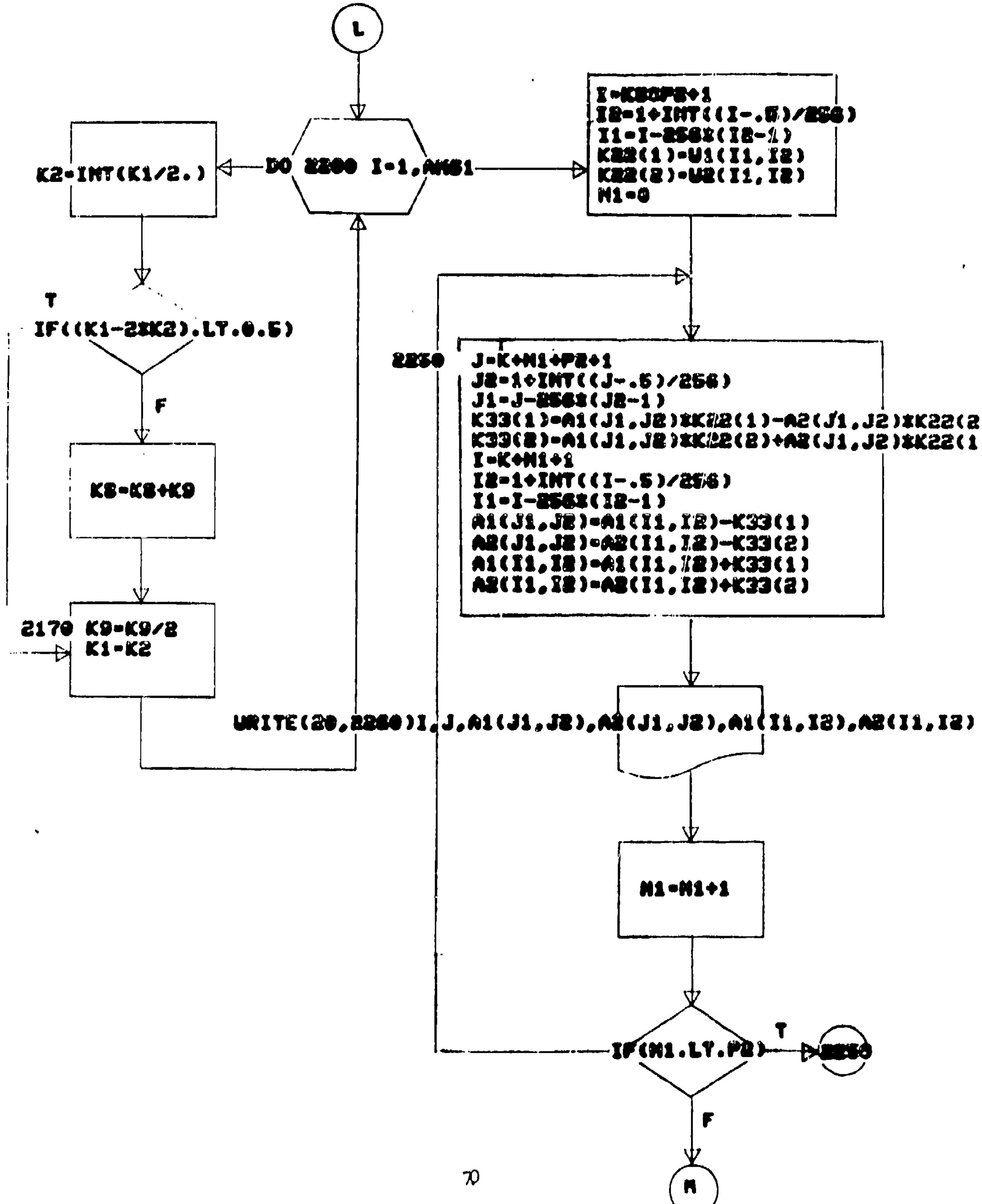

1650
I=N1+2-K
C0=1+INT((I-1.)/256)
R0=I-256*(C0-1)
J=2*I-1
C1=1+INT((J-1.)/256)
R1=J-256*(C1-1)
A1(R1,C1)=A1(R0,C0)
DO 1670 K=1,N1
T
3200
IF(ANSG.EQ.1)
F
H


H
ANS4
3900
3800
4050
ST=A1(1,1)
CO=(INT((IO-1.)/256)+1)
RO=IO-256*(CO-1)
ST=ST+A1(RO,CO)
DO 1700 IO=2,N1
Y=ST/(N1)
A1(1,1)=A1(1,1)-Y
A1(2,1)=A1(2,1)-Y
B1=A1(1,1)
B2=A1(2,1)
X=B1*B1+B2*B2
WRITE(20,1710)
1710 FORMAT(1X,'RELATIVE MAXIMUM & MINIMUM PROFILE VALUES')
IO=1
WRITE(20,1730) IO,B1
1730 FORMAT(1X,I3,5X,F6.2)
I

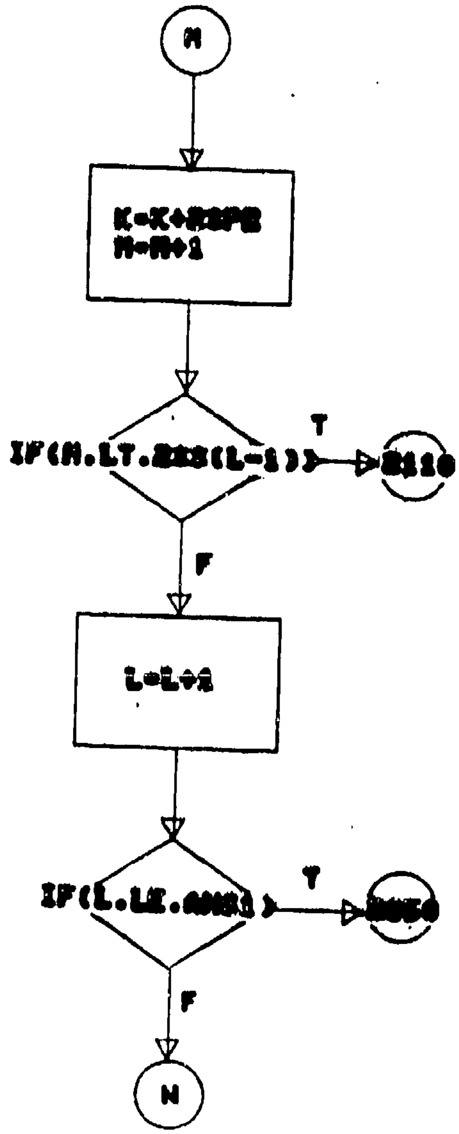

I
RAY1(1,1)=I0
RAY1(2,1)=B1
I01=I0
CO=(INT((I0-1.)/256)+1)
RO=I0-256*(CO-1)
A1(RO,CO)=A1(RO,CO)-Y
B3=B2-B1
B4=A1(RO,CO)-B2
DO 1800 I0=3,N1
WRITE(20,1730) N1,B2
T
IF(B3*B4.GT.0)
F
I01=I01+1
RAY1(1,I01)=N1
RAY1(2,I01)=B2
XLAB1(1)=8HDISTANCE
YLAB1(1)=9HELEVATION
WRITE(20,1730)I0-1,B2
CALL HDCOPY
X=X+(A1(RO,CO))**2
I01=I01+1
RAY1(1,I01)=I0-1
RAY1(2,I01)=B2
B1=B2
B2=A1(RO,CO)
CALL NEWPAG
CALL INITT(300)
J

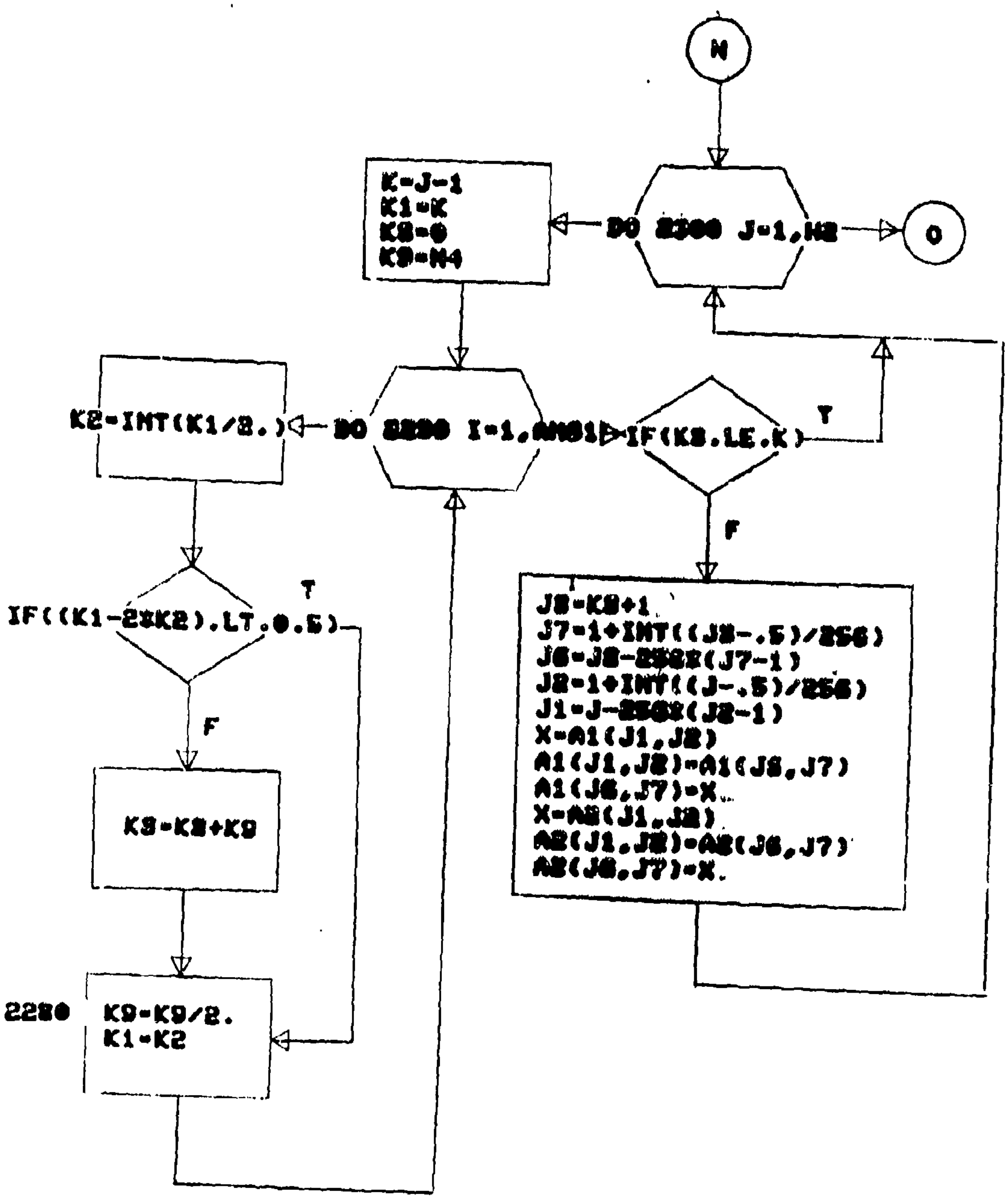

J
CALL GPLOT(RAY1,IO1,XLAB1,8,YLAB1,9,2.,1.,10.,10.,1.,1.,IFLG,0.)
CALL HDCOPY
X=12.*SQRT(X/N1)
WRITE(20,1850) X
1850 FORMAT(///,1X,'RMS FROM DE-TRENDED ZERO MEAN TERRAIN DATA = ',
&F8.3,1X,'INCHES')
K

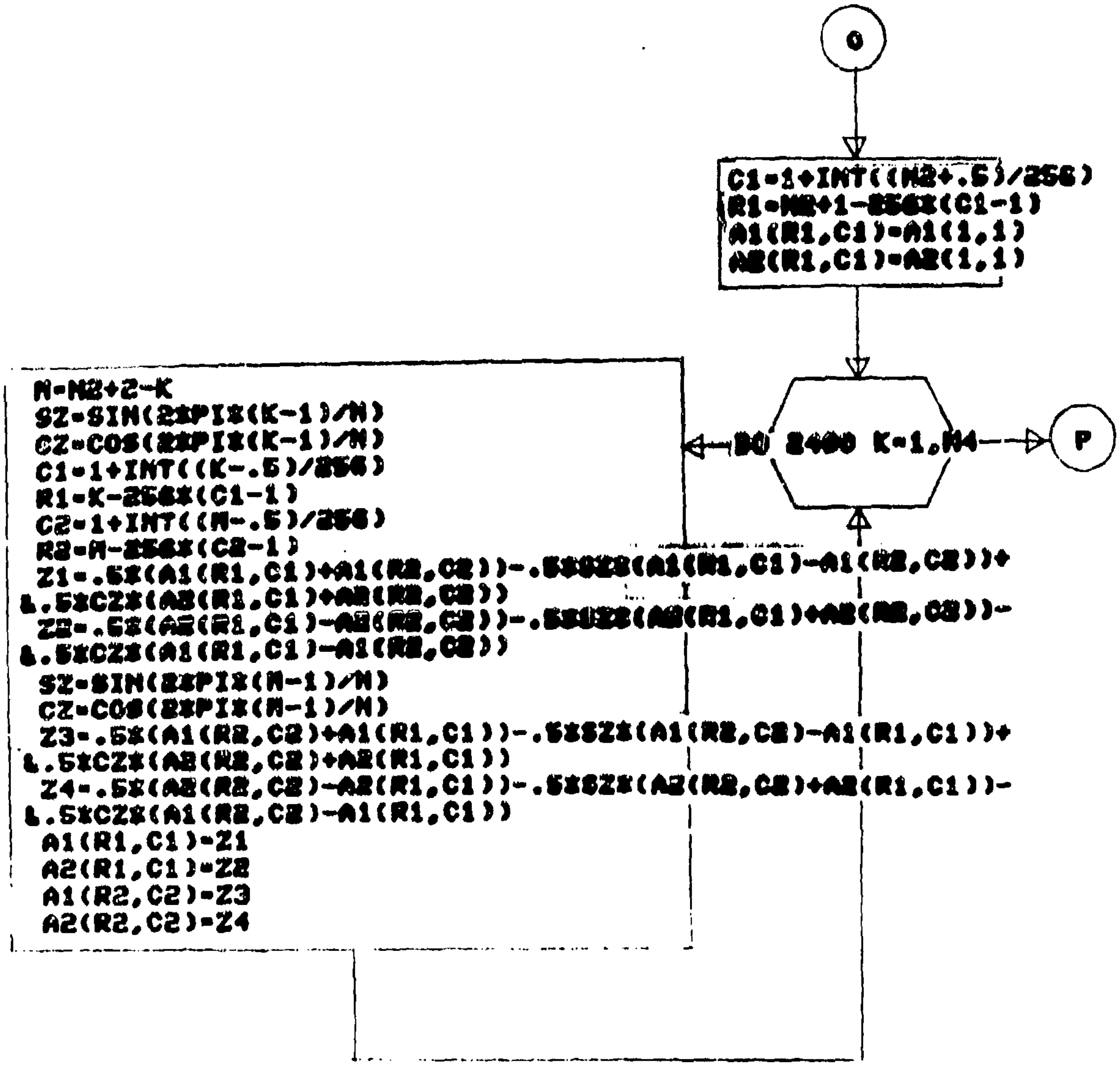

K
N2=N1/2
CO=1+INT((I-1.)/256)
RO=I-256*(CO-1)
I2=2*I
C1=1+INT((I2-1.)/256)
R1=I2-256*(C1-1)
C2=1+INT((I2-2.)/256)
R2=I2-1-256*(C2-1)
A1(RO,CO)=A1(R2,C2)
A2(RO,CO)=A1(R1,C1)
DO 1900 I=1,N2
N=N1
N2=N/2
N3=N1
U1(1,1)=1.
U2(1,1)=0.
U1(2,1)=COS(2*PI/N2)
U2(2,1)=-SIN(2*PI/N2)
I=2
N4=N1/4
K=1+INT((I-.5)/256)
J=I-256*(K-1)
K1=1+INT((I-1.5)/256)
J1=I-1-256*(K1-1)
U1(J,K)=U1(J1,K1)*U1(2,1)-U2(J1,K1)*U2(2,1)
U2(J,K)=U2(J1,K1)*U1(2,1)+U1(J1,K1)*U2(2,1)
DO 2000 I=3,N4
L=1
ANS1=ANS1-1
2050
WRITE(20,1950)I,U1(J,K),U2(J,K)
2050
M=0
P2=INT(2**(ANS1-L)+0.5)
K=0
2110
2110
K1=K
K8=0
K9=N4
L

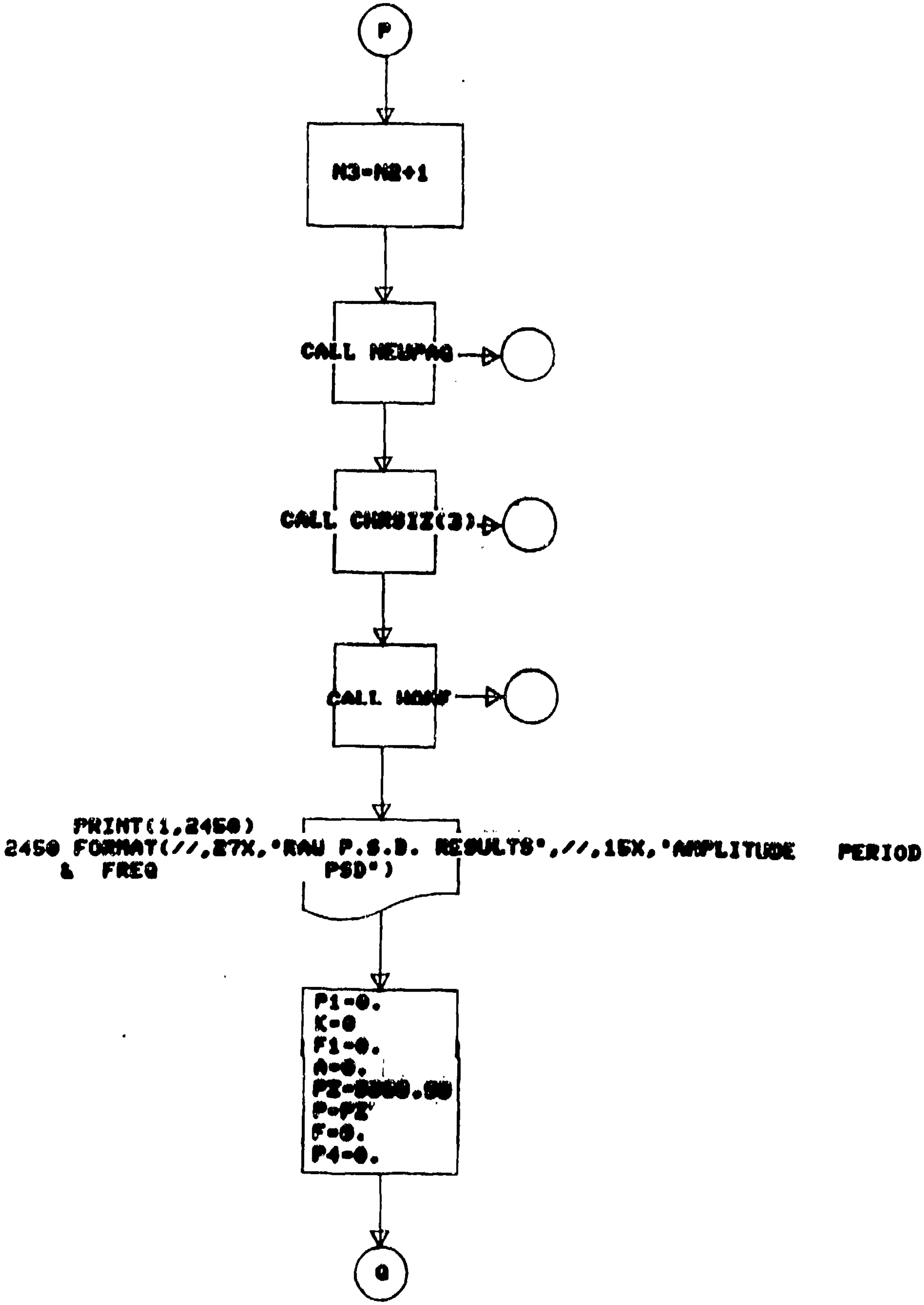


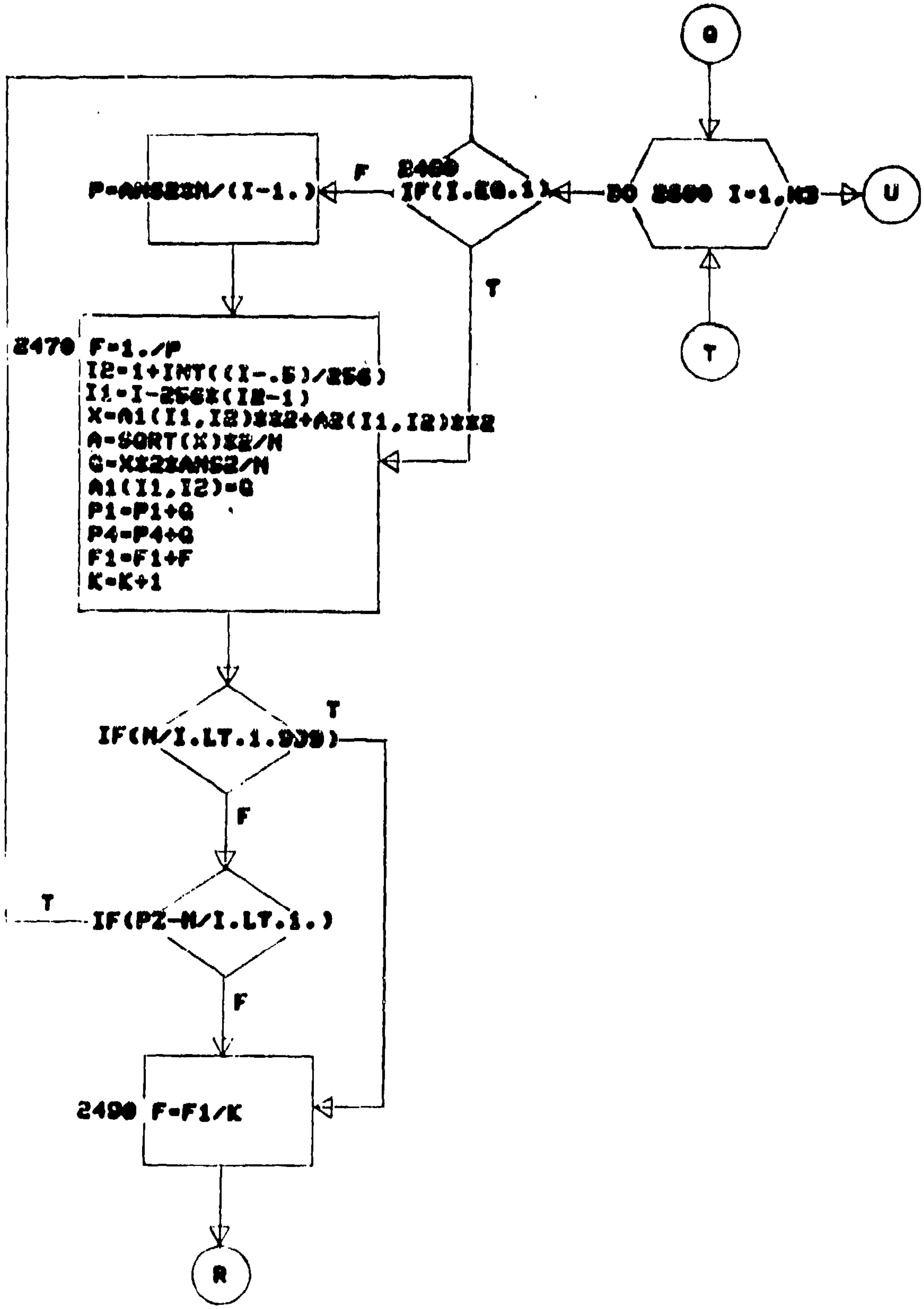
L
K2=INT(K1/2.)
I2=1+INT((I-.5)/256)
I1=I-256*(I2-1)
K22(1)=U1(I1,I2)
K22(2)=U2(I1,I2)
M1=0
T
IF((K1-2*K2).LT.0.5)
F
K8=K8+K9
2170 K9=K9/2
K1=K2
J=K+M1+P2+1
J2=1+INT((J-.5)/256)
J1=J-256*(J2-1)
K33(1)=A1(J1,J2)*K22(1)-A2(J1,J2)*K22(2)
K33(2)=A1(J1,J2)*K22(2)+A2(J1,J2)*K22(1)
I=K+M1+1
I2=1+INT((I-.5)/256)
I1=I-256*(I2-1)
A1(J1,J2)=A1(I1,I2)-K33(1)
A2(J1,J2)=A2(I1,I2)-K33(2)
A1(I1,I2)=A1(I1,I2)+K33(1)
A2(I1,I2)=A2(I1,I2)+K33(2)
WRITE(20,2260)I,J,A1(J1,J2),A2(J1,J2),A1(I1,I2),A2(I1,I2)
M1=M1+1
IF(M1.LT.P2)
T
F
M

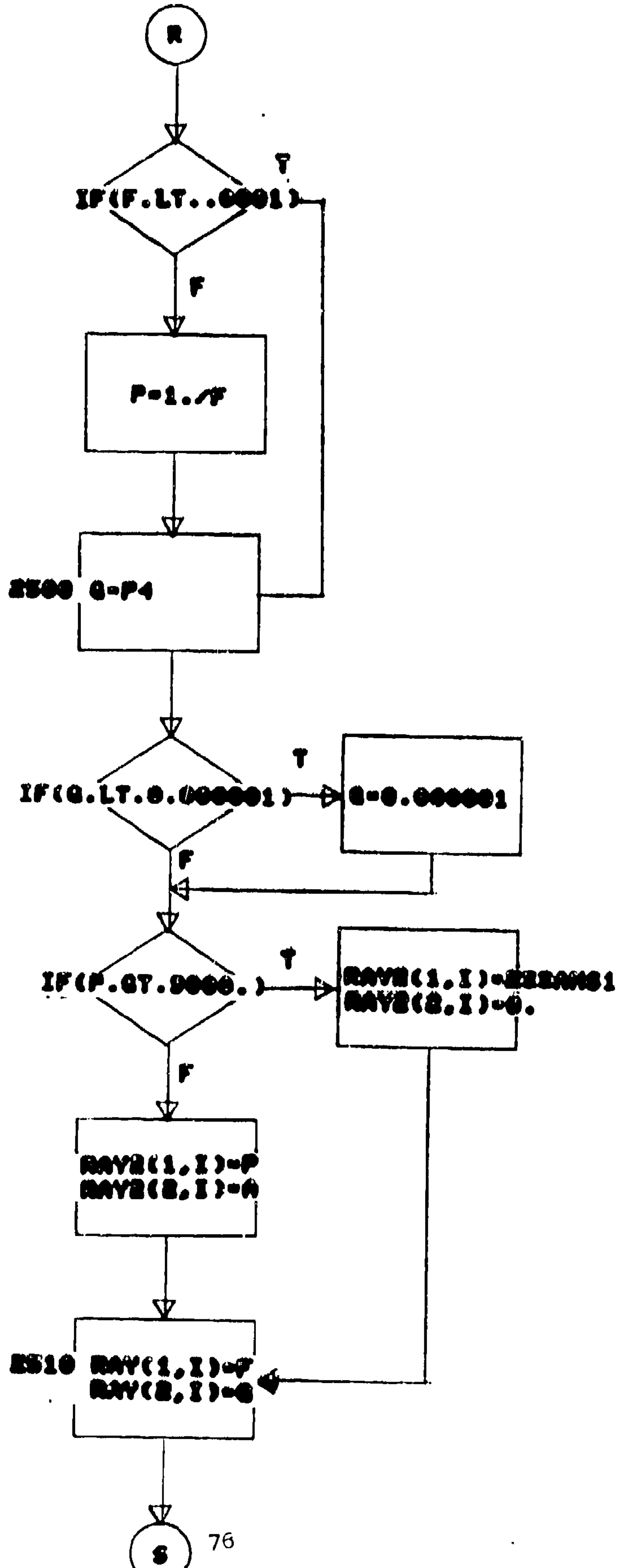

M
M=M+1
T
F
L=L+1
T
F
N

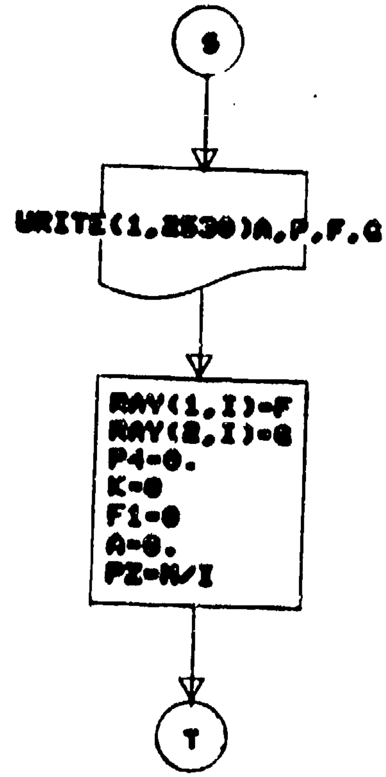

N
K=J-1
K1=K
K8=0
K9=N4
DO 2300 J=1,N2
O
K2=INT(K1/2.)
DO 2200 I=1,NN81
IF(K8.LE.K)
T
F
IF((K1-2*K2).LT.0.5)
T
F
K8=K8+K9
2200
K9=K9/2.
K1=K2
J8=K8+1
J7=1+INT((J8-.5)/256)
J6=J8-256*(J7-1)
J2=1+INT((J-.5)/256)
J1=J-256*(J2-1)
X=A1(J1,J2)
A1(J1,J2)=A1(J6,J7)
A1(J6,J7)=X
X=A2(J1,J2)
A2(J1,J2)=A2(J6,J7)
A2(J6,J7)=X

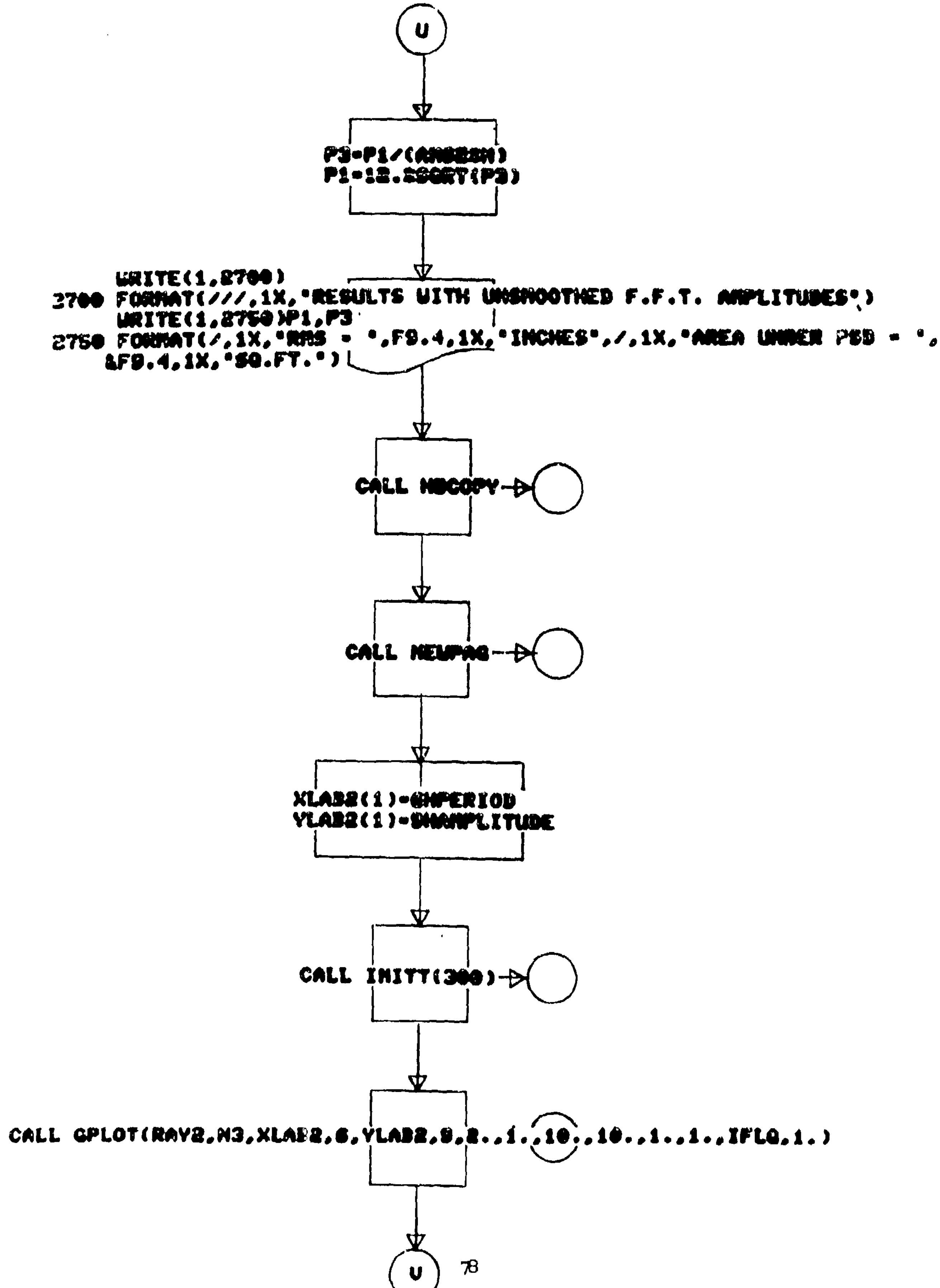

O
C1=1+INT((M2+.5)/256)
R1=M2+1-256*(C1-1)
A1(R1,C1)=A1(1,1)
A2(R1,C1)=A2(1,1)
DO 2400 K=1,M4
P
M=M2+2-K
SZ=SIN(2*PI*(K-1)/N)
CZ=COS(2*PI*(K-1)/N)
C1=1+INT((K-.5)/256)
R1=K-256*(C1-1)
C2=1+INT((M-.5)/256)
R2=M-256*(C2-1)
Z1=.5*(A1(R1,C1)+A1(R2,C2))-.5*SZ*(A1(R1,C1)-A1(R2,C2))+
&.5*CZ*(A2(R1,C1)+A2(R2,C2))
Z2=.5*(A2(R1,C1)-A2(R2,C2))-.5*SZ*(A2(R1,C1)+A2(R2,C2))-
&.5*CZ*(A1(R1,C1)-A1(R2,C2))
SZ=SIN(2*PI*(M-1)/N)
CZ=COS(2*PI*(M-1)/N)
Z3=.5*(A1(R2,C2)+A1(R1,C1))-.5*SZ*(A1(R2,C2)-A1(R1,C1))+
&.5*CZ*(A2(R2,C2)+A2(R1,C1))
Z4=.5*(A2(R2,C2)-A2(R1,C1))-.5*SZ*(A2(R2,C2)+A2(R1,C1))-
&.5*CZ*(A1(R2,C2)-A1(R1,C1))
A1(R1,C1)=Z1
A2(R1,C1)=Z2
A1(R2,C2)=Z3
A2(R2,C2)=Z4

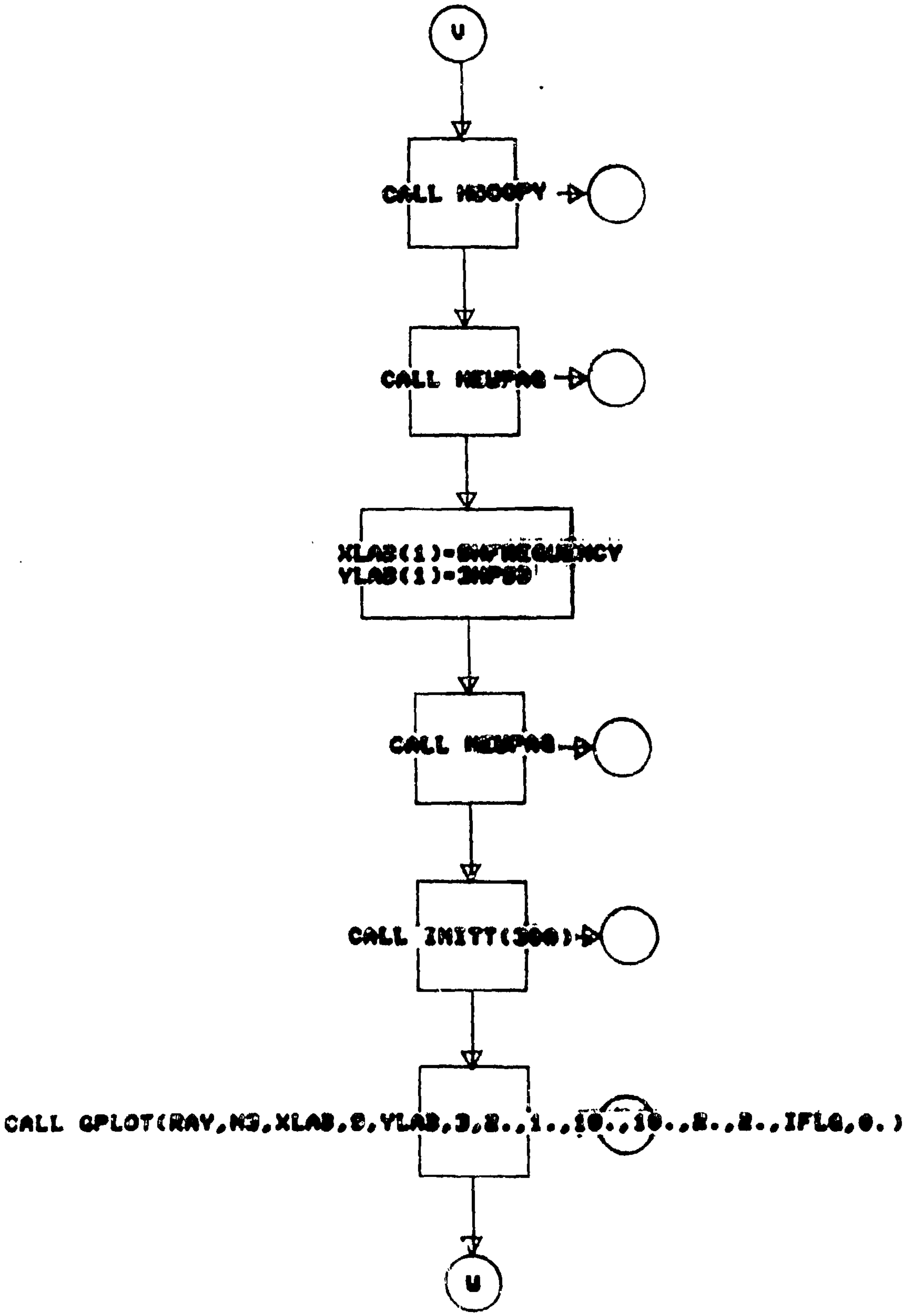

P
N3=N2+1
CALL NEWPAG
CALL CHRSIZ(3)
PRINT(1,2450)
2450 FORMAT(//,27X,'RAW P.S.D. RESULTS',//,15X,'AMPLITUDE PERIOD
& FREQ PSD')
P1=0.
K=0
F1=0.
A=0.
P=PZ
F=0.
P4=0.
Q

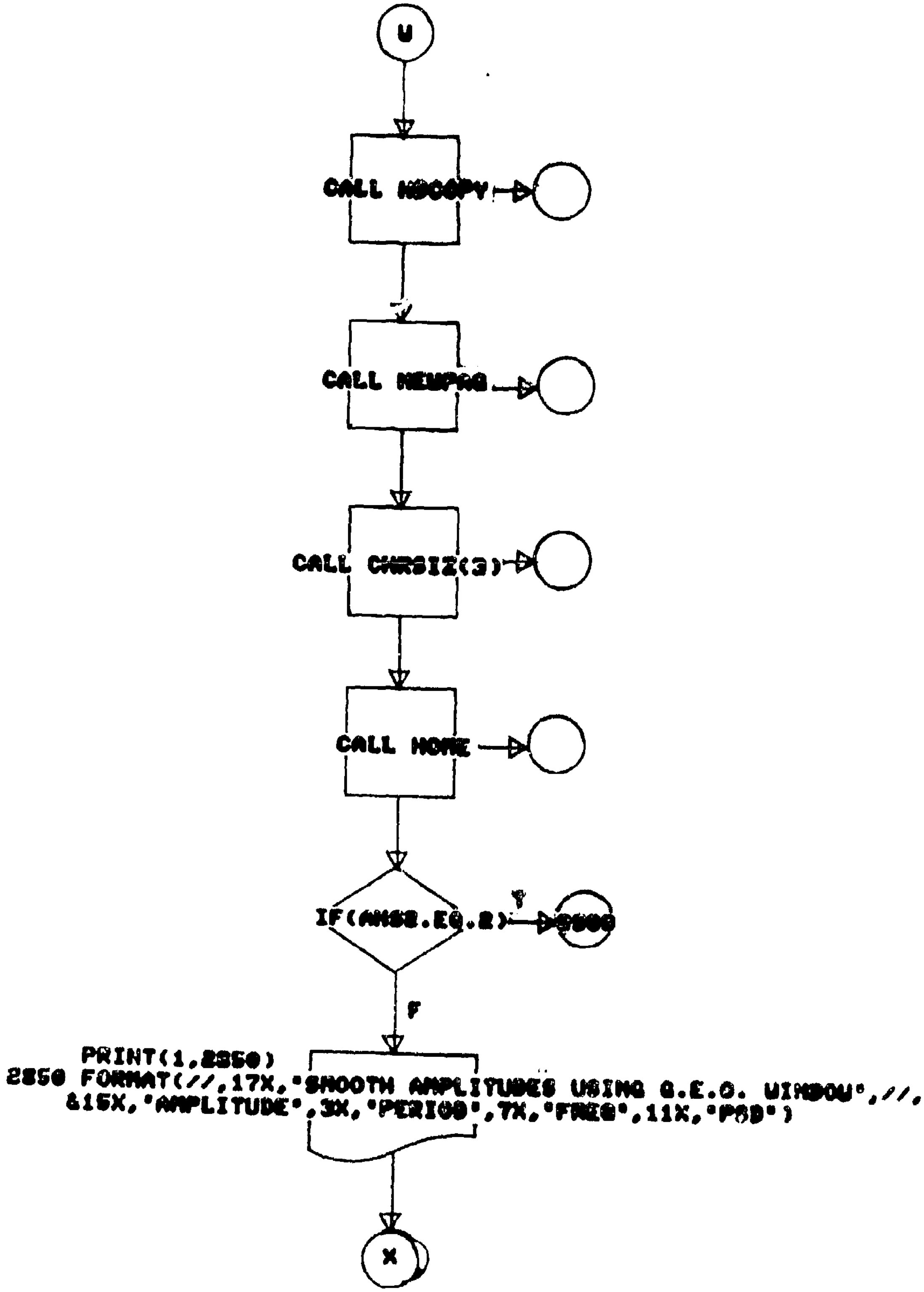

Q
U
T
F
T
P=ANS2*N/(I-1.)
IF(I.EQ.1)
2470 F=1./P
I2=1+INT((I-.5)/256)
I1=I-256*(I2-1)
X=A1(I1,I2)**2+A2(I1,I2)**2
A=SQRT(X)**2/N
G=X**2*ANS2/N
A1(I1,I2)=G
P1=P1+G
P4=P4+G
F1=F1+F
K=K+1
T
F
T
F
2490 F=F1/K
R


R
IF(F.LT..0001)
T
F
P=1./F
IF(G.LT.0.000001)
T
G=0.000001
F
T
F
2510
S

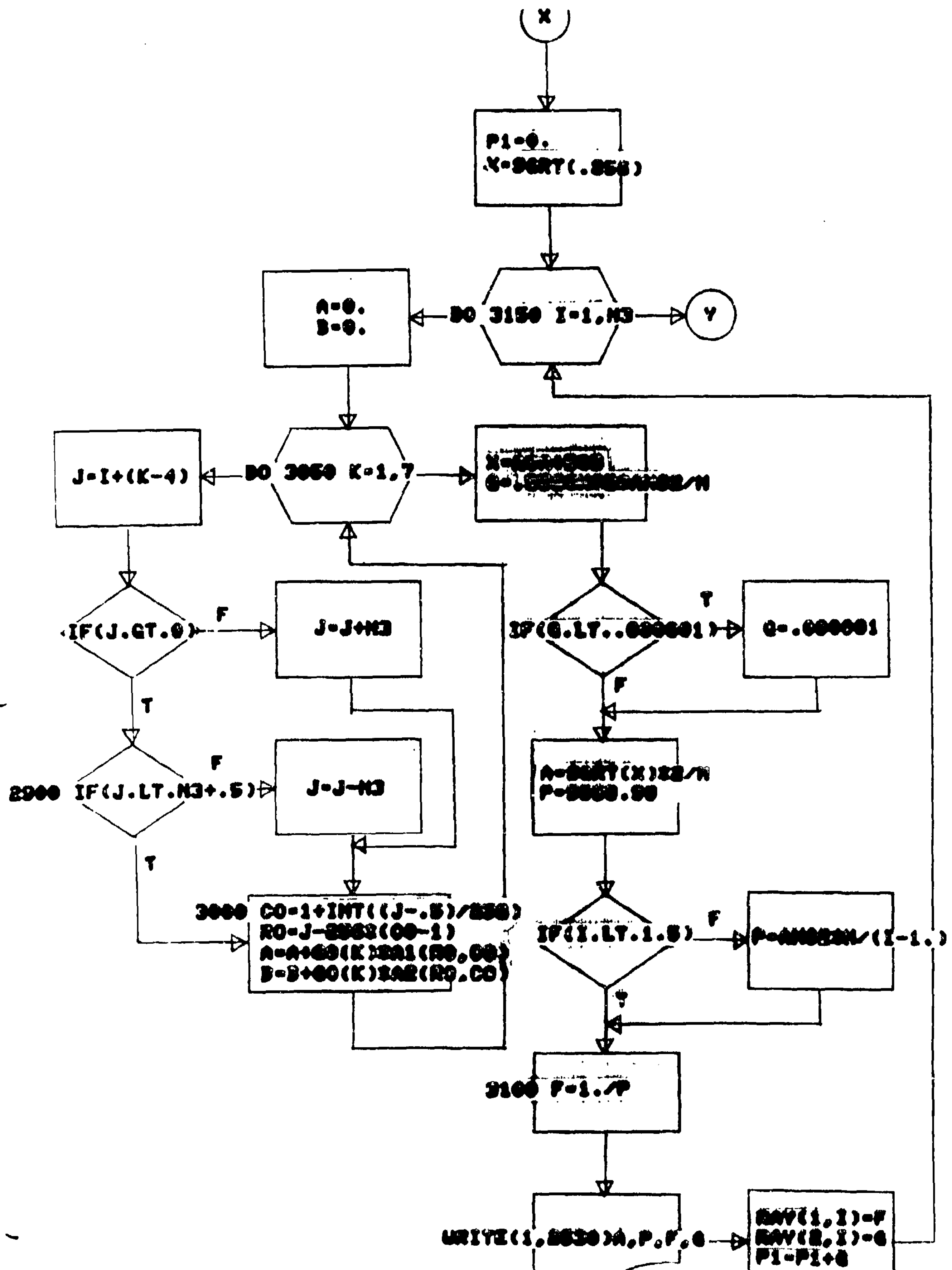

S
WRITE(1,2530)A,P,F,G
RAY(1,I)=F
RAY(2,I)=G
P4=0.
K=0
F1=0
A=0.
PZ=N/I
T

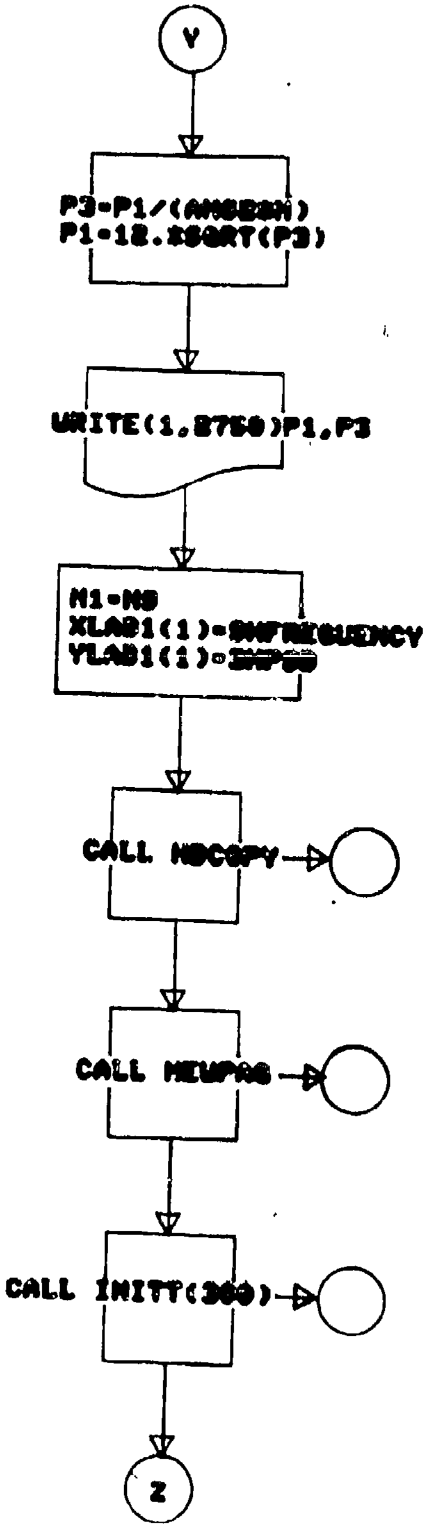

U
P1=12.*SQRT(P3)
WRITE(1,2700)
2700 FORMAT(///,1X,'RESULTS WITH UNSMOOTHED F.F.T. AMPLITUDES')
WRITE(1,2750)P1,P3
2750 FORMAT(/,1X,'RMS = ',F9.4,1X,'INCHES',/,1X,'AREA UNDER PSD = ',
&F9.4,1X,'SQ.FT.')
CALL HDCOPY
CALL NEWPAG
XLAB2(1)=6HPERIOD
YLAB2(1)=9HAMPLITUDE
CALL INITT(300)
CALL GPLOT(RAY2,N3,XLAB2,6,YLAB2,9,2.,1.,10.,10.,1.,1.,IFLG,1.)
U

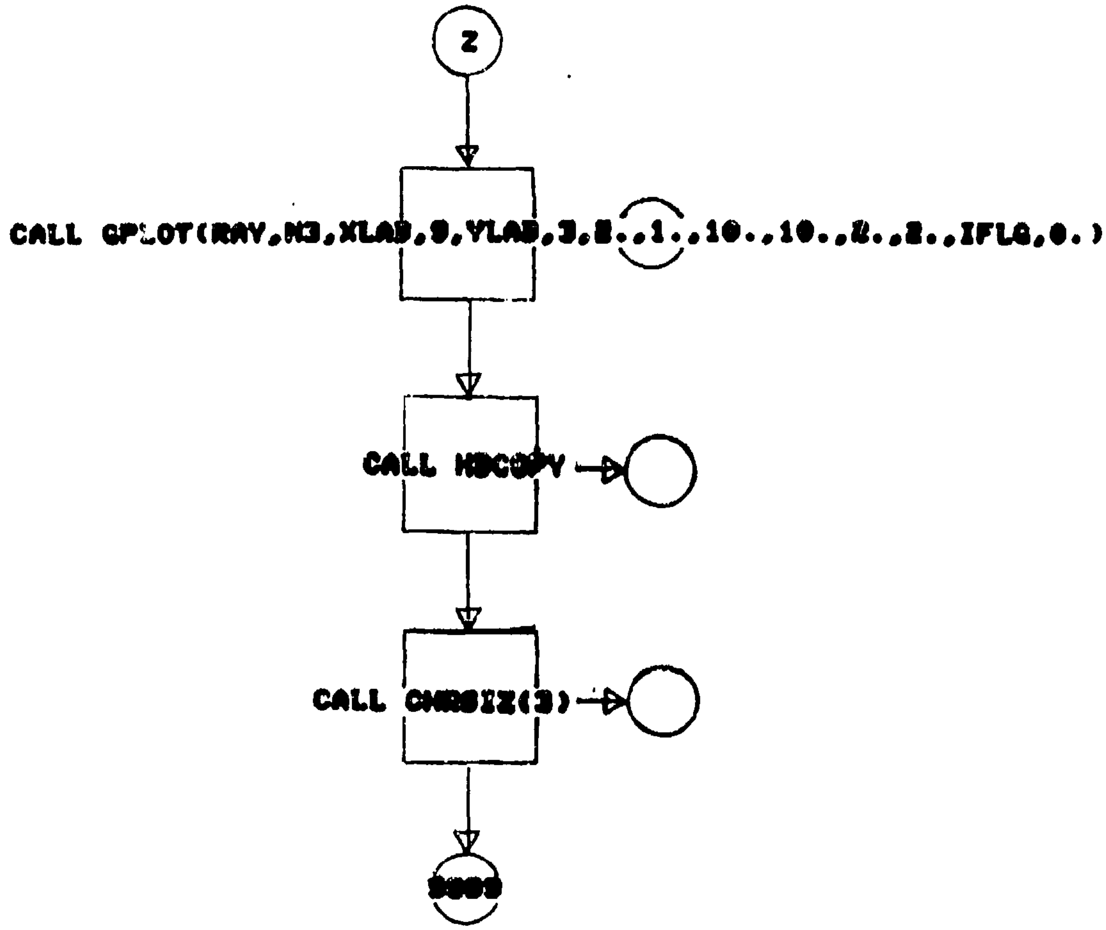

U
CALL HDCOPY
CALL NEWPAG
XLAB(1)=9HFREQUENCY
YLAB(1)=3HPSD
CALL NEWPAG
CALL INITT(300)
CALL GPLOT(RAY,N3,XLAB,9,YLAB,3,2.,1.,10.,10.,2.,2.,IFLG,0.)
U

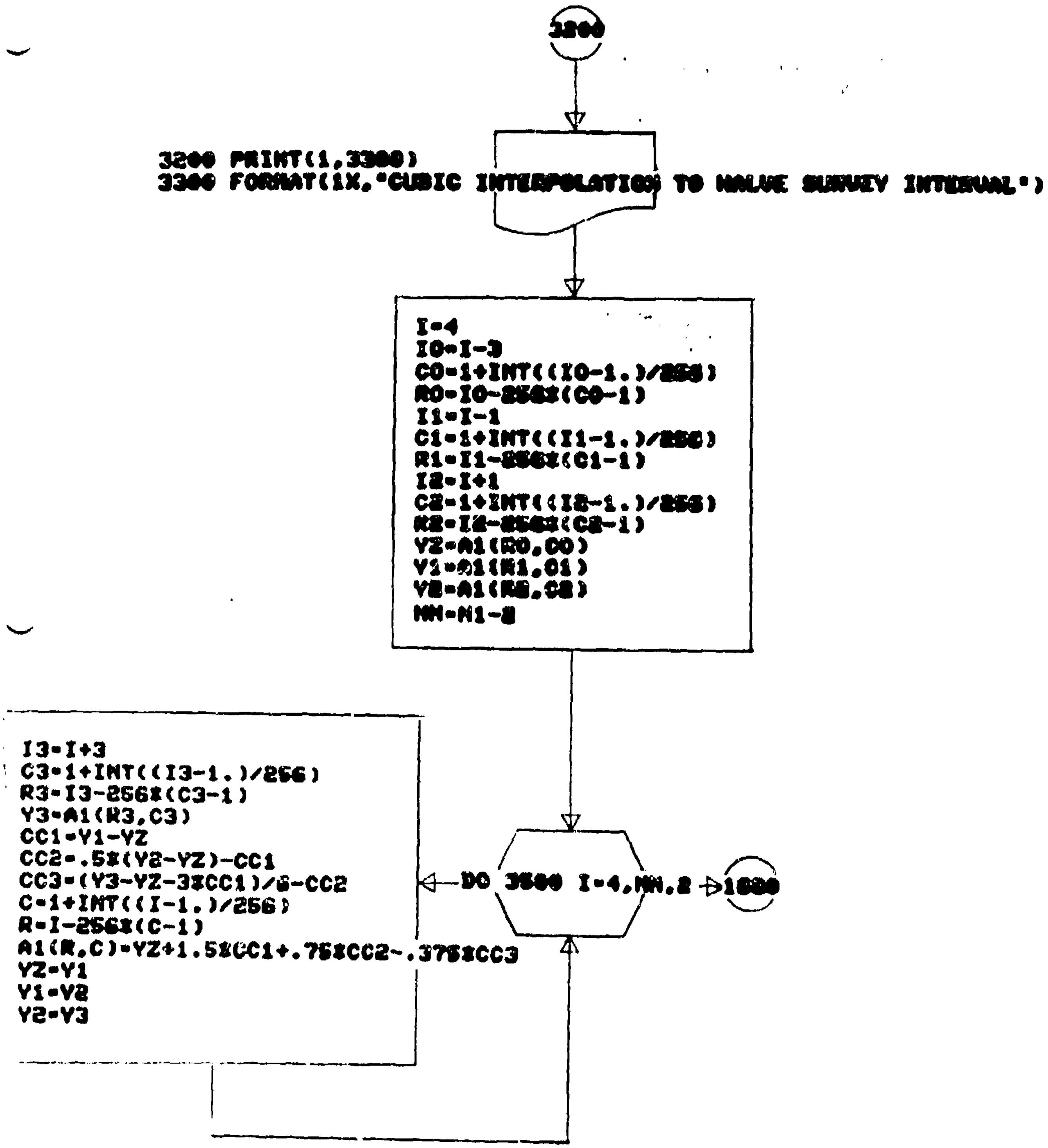


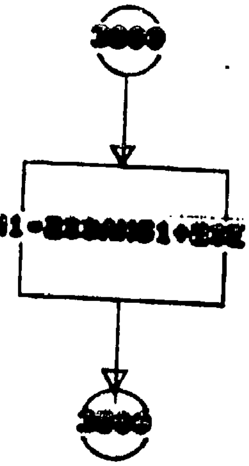
U
CALL HDCOPY
CALL NEWPAG
CALL CHRSIZ(3)
CALL HOME
IF(ANS2.EQ.2)
Y
F
PRINT(1,2850)
2850 FORMAT(//,17X,'SMOOTH AMPLITUDES USING G.E.O. WINDOW',//,
&15X,'AMPLITUDE',3X,'PERIOD',7X,'FREQ',11X,'PSD')
X

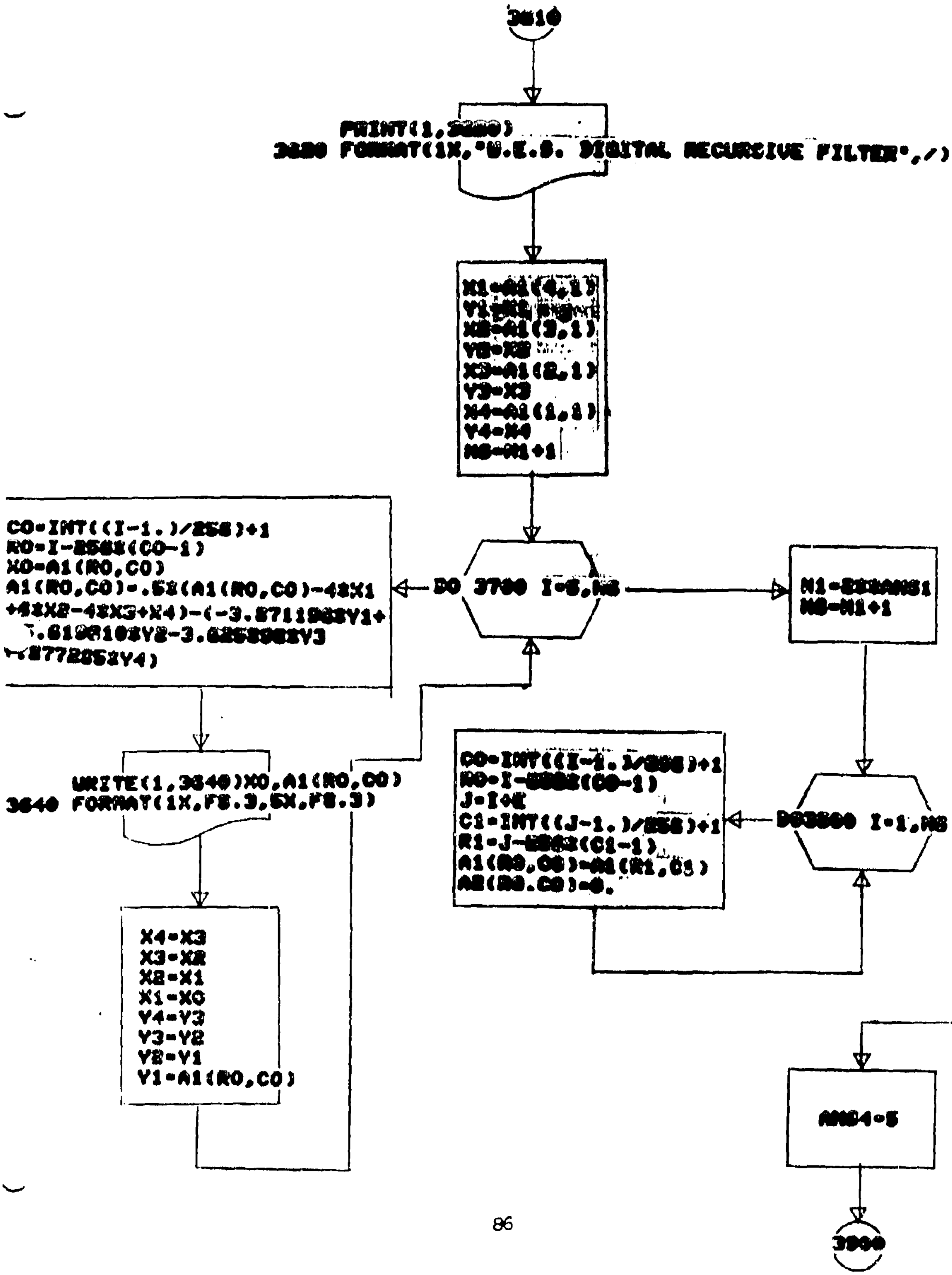

X
PI=0.
DO 3150 I=1,N3
Y
A=0.
B=0.
DO 3050 K=1,7
J=I+(K-4)
IF(J.GT.0)
F
J=J+N3
T
2900 IF(J.LT.N3+.5)
F
J=J-N3
T
IF(Q.LT..000001)
T
Q=.000001
F
IF(I.LT.1.5)
F
T
3100 F=1./P

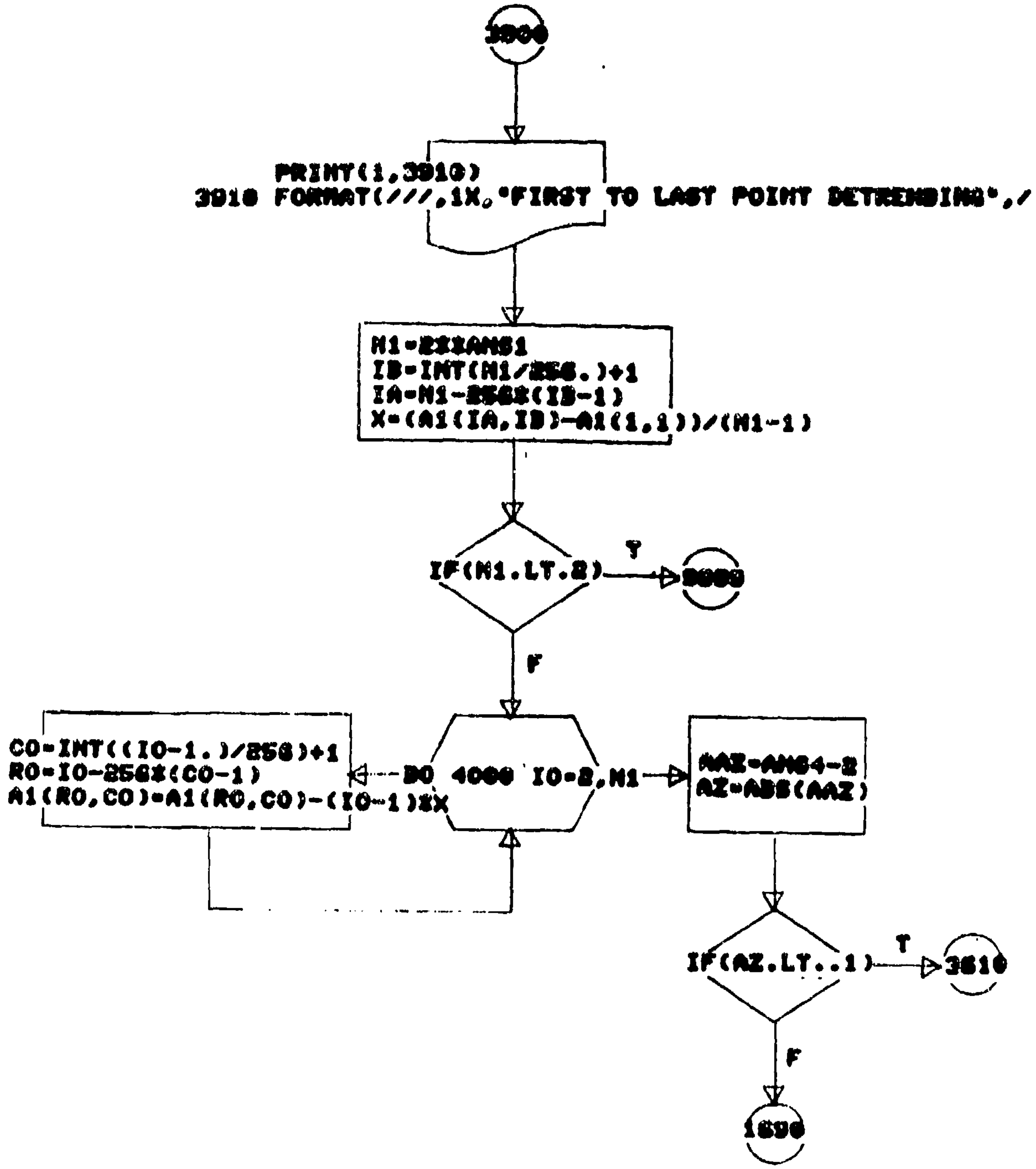

V
P1=12.*SQRT(P3)
WRITE(1,2750)P1,P3
XLAB1(1)=9HFREQUENCY
CALL HDCOPY
CALL NEWPAG
CALL INITT(300)
Z

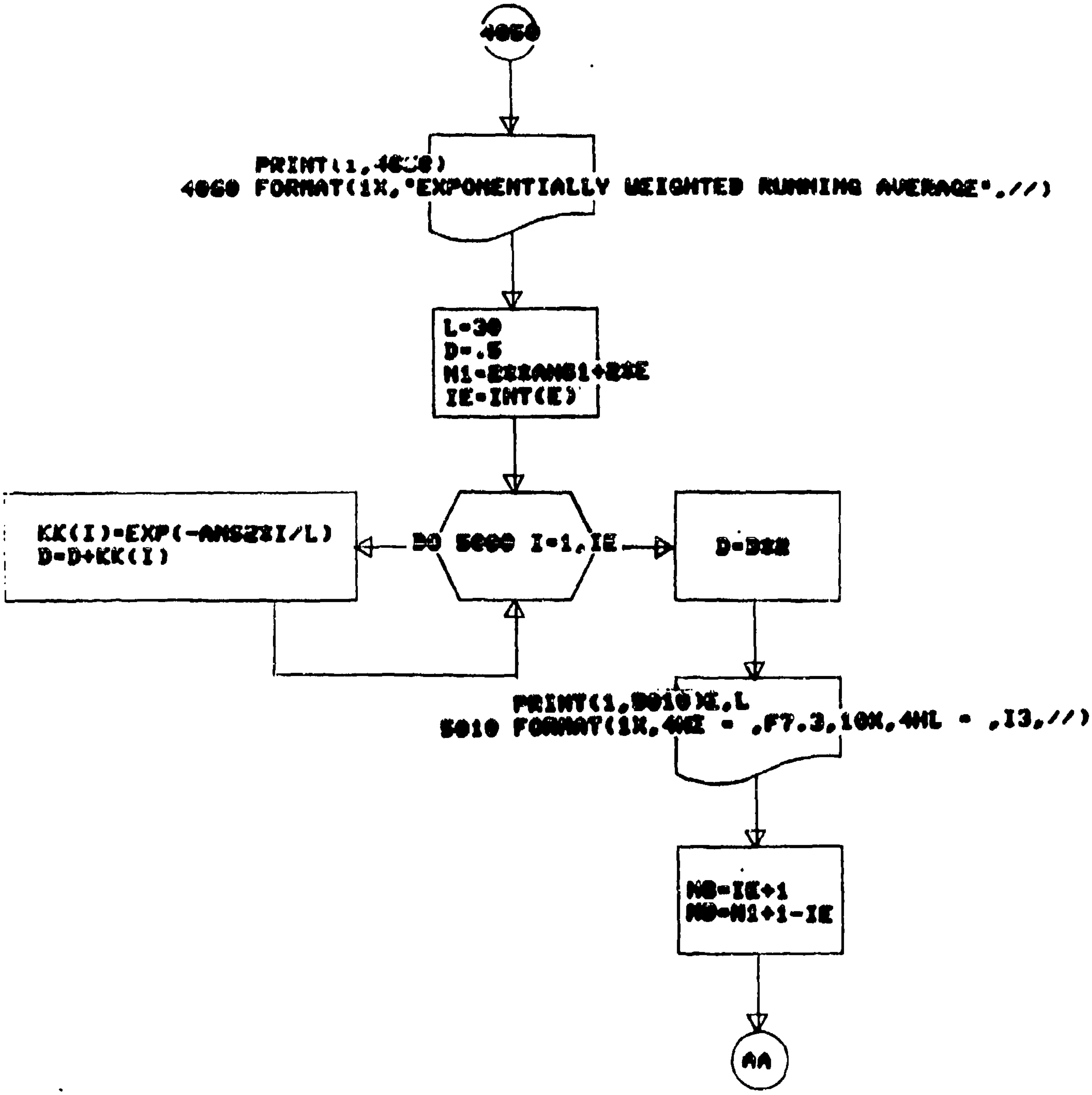

Z
CALL GPLOT(RAY,N3,XLAB,9,YLAB,3,8.,1.,10.,10.,4.,2.,IFLG,0.)
CALL HDCOPY
CALL CHRSIZ(3)

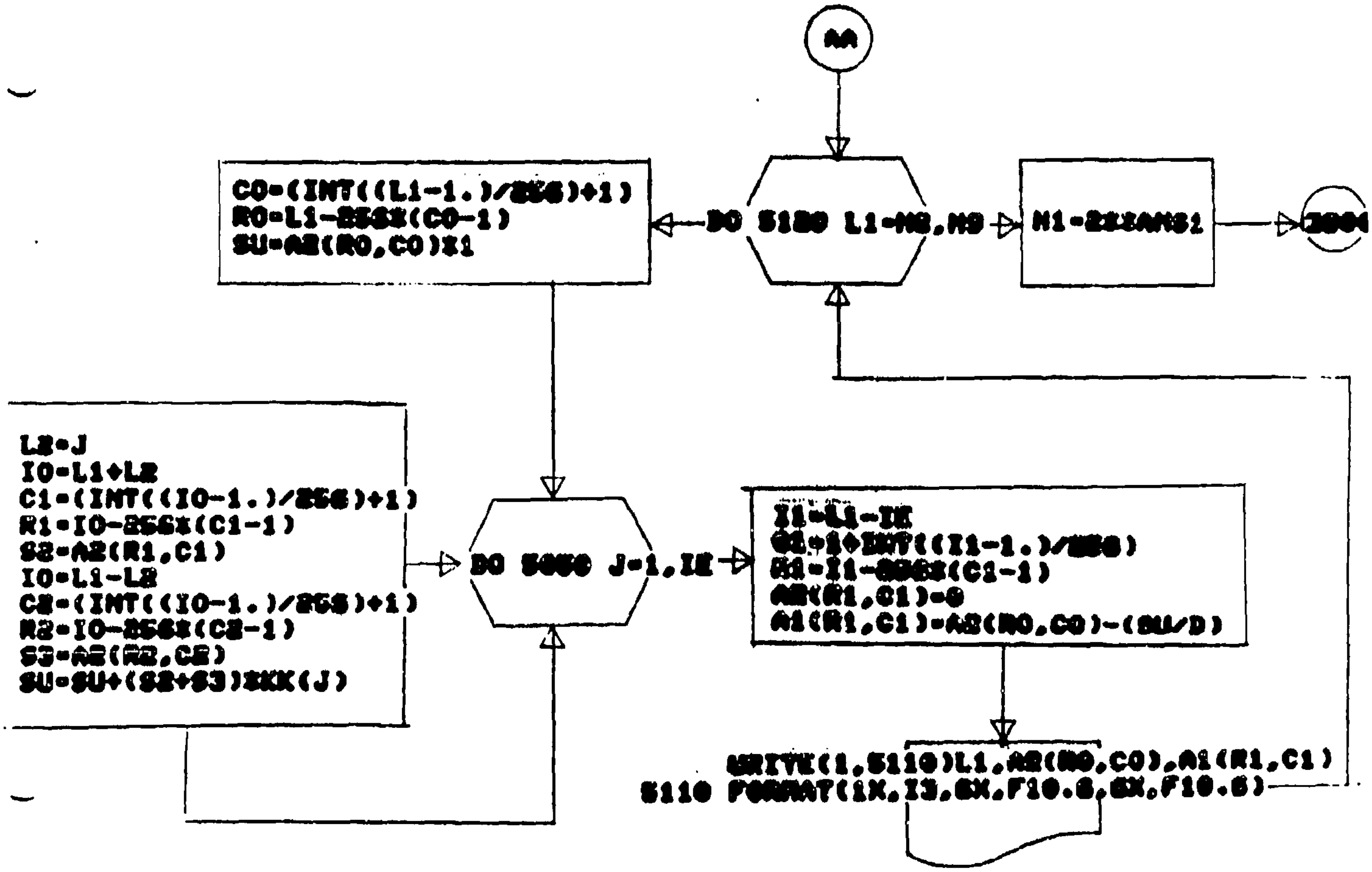

3200
3200 PRINT(1,3300)
3300 FORMAT(1X,"CUBIC INTERPOLATION TO HALVE SURVEY INTERVAL")
I=4
I0=I-3
C0=1+INT((I0-1.)/256)
R0=I0-256*(C0-1)
I1=I-1
C1=1+INT((I1-1.)/256)
R1=I1-256*(C1-1)
I2=I+1
C2=1+INT((I2-1.)/256)
R2=I2-256*(C2-1)
YZ=A1(R0,C0)
Y1=A1(R1,C1)
Y2=A1(R2,C2)
NN=N1-2
I3=I+3
C3=1+INT((I3-1.)/256)
R3=I3-256*(C3-1)
Y3=A1(R3,C3)
CC1=Y1-YZ
CC2=.5*(Y2-YZ)-CC1
CC3=(Y3-YZ-3*CC1)/6-CC2
C=1+INT((I-1.)/256)
R=I-256*(C-1)
A1(R,C)=YZ+1.5*CC1+.75*CC2-.375*CC3
YZ=Y1
Y1=Y2
Y2=Y3
DO 3500 I=4,NN,2
1000

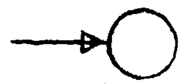



3610
PRINT(1,3620)
3620 FORMAT(1X,"U.E.S. DIGITAL RECURSIVE FILTER",/)
X1=A1(4,1)
X2=A1(3,1)
Y2=X2
X3=A1(2,1)
Y3=X3
X4=A1(1,1)
Y4=X4
CO=INT((I-1.)/256)+1
RO=I-256*(CO-1)
XO=A1(RO,CO)
A1(RO,CO)=.5*(A1(RO,CO)-4*X1
+6*X2-4*X3+X4)-(-3.571198*Y1+
WRITE(1,3640)XO,A1(RO,CO)
3640 FORMAT(1X,F8.3,5X,F8.3)
X4=X3
X3=X2
X2=X1
X1=XO
Y4=Y3
Y3=Y2
Y2=Y1
Y1=A1(RO,CO)
J=I+K
C1=INT((J-1.)/256)+1
3900


PRINT(1,3910)
3910 FORMAT(///,1X,"FIRST TO LAST POINT DETRENDING",/)
N1=2**ANS1
IB=INT(N1/256.)+1
IA=N1-256*(IB-1)
X=(A1(IA,IB)-A1(1,1))/(N1-1)
IF(N1.LT.2)
T
F
DO 4000 IO=2,N1
CO=INT((IO-1.)/256)+1
RO=IO-256*(CO-1)
A1(RO,CO)=A1(RO,CO)-(IO-1)*X
AAZ=ANS4-2
AZ=ABS(AAZ)
IF(AZ.LT..1)
T
3810
F


4050
PRINT(1,4060)
4060 FORMAT(1X,'EXPONENTIALLY WEIGHTED RUNNING AVERAGE',//)
L=30
D=.5
N1=E**ANS1+2*E
IE=INT(E)
KK(I)=EXP(-ANS2*I/L)
D=D+KK(I)
DO 5000 I=1,IE
D=D*2
PRINT(1,5010)E,L
5010 FORMAT(1X,4HE = ,F7.3,10X,4HL = ,I3,//)
N0=IE+1
N0=N1+1-IE
AA


AA
CO=(INT((L1-1.)/256)+1)
RO=L1-256*(CO-1)
SU=A2(RO,CO)*1
DO 5100 L1=N8,N9
N1=2**ANS1
L2=J
IO=L1+L2
C1=(INT((IO-1.)/256)+1)
R1=IO-256*(C1-1)
S2=A2(R1,C1)
IO=L1-L2
C2=(INT((IO-1.)/256)+1)
R2=IO-256*(C2-1)
S3=A2(R2,C2)
SU=SU+(S2+S3)*KK(J)
DO 5050 J=1,IE
I1=L1-IE
C1=1+INT((I1-1.)/256)
R1=I1-256*(C1-1)
A2(R1,C1)=0
A1(R1,C1)=A2(RO,CO)-(SU/D)
WRITE(1,5110)L1,A2(RO,CO),A1(R1,C1)
5110 FORMAT(1X,I3,5X,F10.6,5X,F10.6)



INDICATE CALL SUBROUTINE, THE STEPS OF WHICH ARE NOT INCLUDED IN THE FORTRAN PROGRAM, BUT ARE IN MAIN STORAGE. AFTER PROCESSING, CONTROL IS RETURNED TO THE MAIN PROGRAM.

APPENDIX I

TERRAIN CHARACTERIZATION

BY

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TERRAIN CHARACTERIZATION

OBJECTIVE:

The objective of this research is to characterize random terrain profiles by several parameters such as predominant frequency (CPS) content as a function of vehicle velocity, power spectral density (PSD), frequency (CPF), PSD slope and a "detrending parameter".

Additionally, natural terrain possesses a roll statistic or natural offset and research will be conducted to identify it in terms of a vehicle's geometric properties and the autocorrelation function between terrain profiles which are different but possess the same root-mean-square (RMS) level.

SCIENTIFIC APPROACH:

There are many statistical methods for analyzing random data. This task will investigate the techniques developed for time-dependent data and apply them to time-independent but spatially dependent data to develop autocorrelation functions, root-mean-square values, and power-spectral-density plots for terrain profiles.

PROGRESS:

A. BACKGROUND

Investigations this year were focused on the analysis of terrain geometry by means of statistical techniques. The use of statistics is traditional and well documented in many references. A terrain profile as measured along a line of finite distance is one sample record, $y(x)$. A random process is the collection $\{y(x)\}$, of all sample records contained within the boundary of the terrain unit under investigation.

The validity of the statistical analysis depends on two properties exhibited by the random process: stationarity and ergodicity. To clarify this, assume the existence of a finite collection of sample records from a random process, and now examine the value of each sample record $y(x)$ at some arbitrary point x_1. The mean value of the random process at x_1 is:

$$\mu_y(x_1) = \frac{1}{N}\sum_{K=1}^{N} y_k(x_1).$$

This is also called the first moment. The correlation (called the autocorrelation function) between two points x_1 and $x_1 + \Delta$ is defined as:

$$R_y(x_1, x_1 + \Delta) = \frac{1}{N} \sum_{K=1}^{N} y_k(x_1)\, y_k(x_1 + \Delta).$$

To be very rigorous, these expressions are valid only in the limit as $N \to \infty$. The random process $y(x_1)$ is weakly stationary if $\mu_y(x_1)$ and $R_y(x_1, x_1 + \Delta)$ are invariant as x_1 varies over all x; i.e., $\mu_y(x_1) = \mu_y$ and $R_y(x_1, x_1 + \Delta) = R_y(\Delta)$ for all points x within the collection of sample points. This means that the mean value of the elevation for the terrain unit is constant and that the autocorrelation function is dependent only on the separation distance between two points. Note that if Δ is zero, then the square root of the autocorrelation function is the RMS of the terrain profile. In order for a random process $\{y(x)\}$ to be strongly stationary, all higher order moments and joint moments for the autocorrelation function must be invariant with respect to the variable x. For many practical applications, a verification of weak stationarity justifies the assumption of strong stationarity. In any case, the collection of all higher order moments and joint moments can be used to establish a complete family of probability distribution functions that describe the random process.

Consider the <u>k</u>th sample record $y_k(x)$. The mean value and autocorrelation function of <u>k</u>th sample record is given by:

$$\mu_y(k) = \frac{1}{X} \int_0^X y_k(x)\, dx \text{ and } R_y(\Delta,k) = \frac{1}{X} \int_0^X y_k(x)\, y_k(x + \Delta)\, dx$$

If the random process $\{y(x)\}$ is stationary, and $\mu y(k)$ and $R_y(\Delta,k)$ are constant for all values of k, then $\mu_y(k) = \mu_y$ and $R_y(\Delta,k) = R_y(\Delta)$, and therefore the process is ergodic. Note that only stationary random processes can be ergodic.

Therefore, if it is assumed that a terrain unit is a random process that is both stationary and ergodic, then all the necessary information can be obtained from one sample terrain profile.

B. <u>COMPUTATIONAL PROCEDURES:</u>

Making these assumptions allows the statistical analysis of a single terrain profile to produce a root-mean-square

roughness value and a power spectral density distribution plot which portray the characteristics of the terrain unit which is geographically associated with the sample. The general process is as follows:

1. Conduct a survey in the area for which information is required. Establish a path (not necessarily absolutely straight) between 400 - 600 feet long and determine the elevation of the profile at one foot intervals.

2. Detrend the raw data by removing low frequency information. Normally a cut off frequency of .0166 cycles/ft is used. (Detrending is discussed later).

3. Set the detrended profile to have a zero mean.

4. Calculate the autocorrelation function. The square root of the autocorrelation function with Δ equal to zero is the RMS of the profile.

5. Operate on the autocorrelation function using Fourier Transforms to yield raw power spectral density estimates.

6. Apply smoothing coefficients and calculate the central frequency for each PSD estimate. (PSD is established for a various frequency/band).

7. Graphic presentation.

Steps 2 through 6 have been written into a computer program, using basic language for a Wang 2200 series computer. Raw survey data are entered in a data block and the finished product consists of a listing of smoothed power spectral density estimates and associated center frequencies. Terrain profiles up to 699 feet long may be processed, with up to 200 autocorrelation coefficients. At the operator's discretion, any one of four methods of detrending may be used or he may ignore detrending.

Steps 3, 4, 5, and 6 are well documented in many references. All authorities agree, so there is little need for discussion. However, Step 2, detrending, is not as clear cut. There are several techniques available, none of which are ideal. However, detrending is important because it drastically alters the RMS value and the shape of the PSD plot. It is necessary because of the statistical nature of the data reduction process. In order for the

process to identify all frequencies which are present, the sample record must be several times longer than the wave length of the lowest frequency. Since the frequency content is unknown, all frequencies below a certain limit must be eliminated and a sample record length several times longer than the wave length of the cut off frequency must be used. If the removal of long wave length information, or a net change in elevation, is not accomplished, the reduction process will distribute the associated "power" throughout the entire spectrum of the PSD plot. Furthermore, if a net change in elevation does occur, it will invalidate the assumption of ergodicity. This, of course, destroys the value of the analysis.

Detrending is often called filtering. The type of filter which is of interest in terrain profile analysis would be a high pass filter; i.e., those frequencies lower than the cut off frequency are filtered out and those above the cut off frequency are passed. Unfortunately, there are no ideal mathematical filters; no mathematical data manipulation will entirely eliminate the frequencies lower than the limit and leave the higher frequencies unchanged. There is always some distortion of information on the pass side of the filter and some passing of information on the filter side. The best that can be done is to look for the filter with the sharpest possible cut off characteristics and minimal distortion on the "pass" side. Much of the effort in FY76 was directed to this end. Several filtering techniques were investigated but only two proved to be promising.

One such numerical filter is known as the running average. It is a two sided filter that detrends without a phase shift and is able to remove linear trends as well as long wave length information. The filter calculates a correction factor for each point in the survey. The correction factor is then subtracted from the value of each survey point to yield a corrected value. The series of corrected values forms a new "detrended" profile devoid of long wave length information. The correction factor for each survey point is calculated by summing the elevations at a given number of points ahead of and behind the point to be detrended, plus the value of the point itself and dividing the sum by the total number of points. The mathematical expressions are as follows:

$$y_m(X) = \frac{1}{\ell+1} \sum_{k = -\ell/2}^{k = \ell/2} y(X + K\Delta X);\ K = -\frac{\ell}{2}, \left(-\frac{\ell}{2} + 1\right), \ldots 0, \ldots \frac{\ell}{2}$$

where:

$y_m(X)$	= the correction factor to be subtracted from the ordinate of the surveyed point
ℓ	= number of survey points
$\ell \cdot \Delta X$	= length of running average
$y(X)$	= value of any point in the original survey
X	= horizontal distance
ΔX	= measurement interval

Note than the raw values are used throughout the process. The previously corrected values are ignored during detrending. The detrended profile is generated by:

$$\overline{Y}(X) = y(X) - y_m(X)$$

where:

$\overline{Y}(X)$ = the ordinate of the detrended survey point. This technique generates a unique correction factor for each survey point.

The cut off frequency of this filter is controlled by the number of survey points and measurement interval included in the averaging. For example, if the survey interval is one foot and the filter looks ahead and behind 30 points, then the cut off frequency is approximately .0166 cycles/ft (corresponding to a 60 foot length). The error function concerning this process is:

$$\delta(\Omega) = \frac{1 - 2 \sin (\Omega D/2)}{\Omega D}$$

where:

$$D = (\ell + 1)\Delta X$$

ℓ = number terms for averaging

ΔX = survey interval

Ω = frequency

Figure 1 shows a plot of the error function for filters which look ahead and behind 33, 50, and 70 survey points. It shows that the filters have sharp cut off characteristics but that they also distort frequency amplitudes in the pass side of the filter. For each error function shown, the first zero error point occurs very nearly at the frequency whose wave length is equal to the length of the running average. Thereafter, the filter alternately over and under estimates the amplitudes. The maximum over estimation is almost 50%; the maximum under estimation is a little more than 20%. However, the decay characteristic quickly reduces the distortion to $\pm$ a few percent.

The second filter, introduced by Van Deusen, is a modification of the running average. It is termed a "moving two sided exponentially weighted average." A correction factor is calculated in the same manner except that the values used in the calculation are weighted proportionally to their distance from the point being detrended. The more distant points are less influential than nearby points. The weighting is accomplished by an exponential factor. Mathematically the filter expression is:

$$y_n(X) = \frac{\sum_{\ell = 0}^{E} \{y(X + \ell \cdot \Delta X) + y(X - \ell \cdot \Delta X)\} \exp(- \frac{\ell \cdot \Delta X}{\lambda})}{\sum_{\ell = 0}^{E} \exp(- \frac{\ell \cdot \Delta X}{\lambda})}$$

where: $y(X)$ = elevation at the point X

$y_n(X)$ = correction factor

ℓ = step number

ΔX = measurement interval

λ = weighting constant

then:

$$\overline{Y}(X) = y(X) - y_n(X)$$

where:

$\overline{Y}(X)$ = value of detrended profile point.

Lamda is an independent variable which is chosen to establish the cut off frequency. Then in actual computation, a limit on the value of the exponent is set that causes ℓ to be limited to some finite number E. Van Deusen chose to cut off computation when the absolute value of the exponent exceeded 3. By adjusting the value of lamda and the limit on the value of the exponent, filter characteristics can be modified over a wide range. If values are assigned which cause a rapid decline in the value of the survey points used in computing $\overline{Y}(X)$, the error function will exhibit a general under estimation of amplitudes in the pass side of the filter. An example of this phenomenon of weighting is shown in Figure 2 for three different values of Lamda.

The considerable effort was directed at investigating the weighting constant and its effect on optimizing filter characteristics. The result is an improved filter which has better cut off characteristics and limits distortion in the pass side of the filter to less than 10%. The error function is shown in Figure 3. The summation of terms for averaging is stopped when the absolute value of the exponent exceeds 1.2 with Lamda = 30. The filter parameters were chosen to less severely depress the values of the survey points in computing $\overline{Y}(X)$. Note that some of the oscillatory characteristics of the straight running average error function are evident. This improved filter has been incorporated in the PSD computer program and is regularly used for detrending field survey data.

The most noticable effect of detrending techniques occurs in the calculation of the RMS value of a profile. Even slight changes can cause large variations in the RMS value. If we wish to be very precise, then even the improved filter cannot stand alone because it does pass some low frequency information which ideally it should not. Additional filtering can be done graphically on the final plot of the PSD. The square root of the area under the PSD plot is the RMS of the profile. By subtracting the area in the low frequency end of the plot from the total area, the profile can be further detrended. This combination of numerical and graphical filtering produces RMS values as close to the true values as possible with the statistical analysis technique.

FUTURE PLANS:

As a result of the work described here, a computer program is available that produces RMS and PSD data from terrain profile survey data. The procedure uses an improved mathematical filter to eliminate undesirable wave lengths and slopes. It also smoothes the PSD plots by reducing the side lobes which occur due to the limited length of the surveyed profile.

The procedure is based on the Wiener-Khinchin equation which states that the PSD is the Fourier transform of the autocorrelation function. Hence, one calculates the autocorrelation function first. (The practical application was first published by Blackman and Tukey).

However, a more direct approach, the computation of the Fourier transform of the profile itself, is now a practical proposition because a new, faster computational method has been developed for the performance of Fourier transform calculations.

It is, therefore, recommended that the application of the Fast Fourier Transform method to terrain profile analysis be undertaken next.

attenuation
~~ERROR~~ FUNCTION FOR RUNNING

AVERAGE DETRENDING

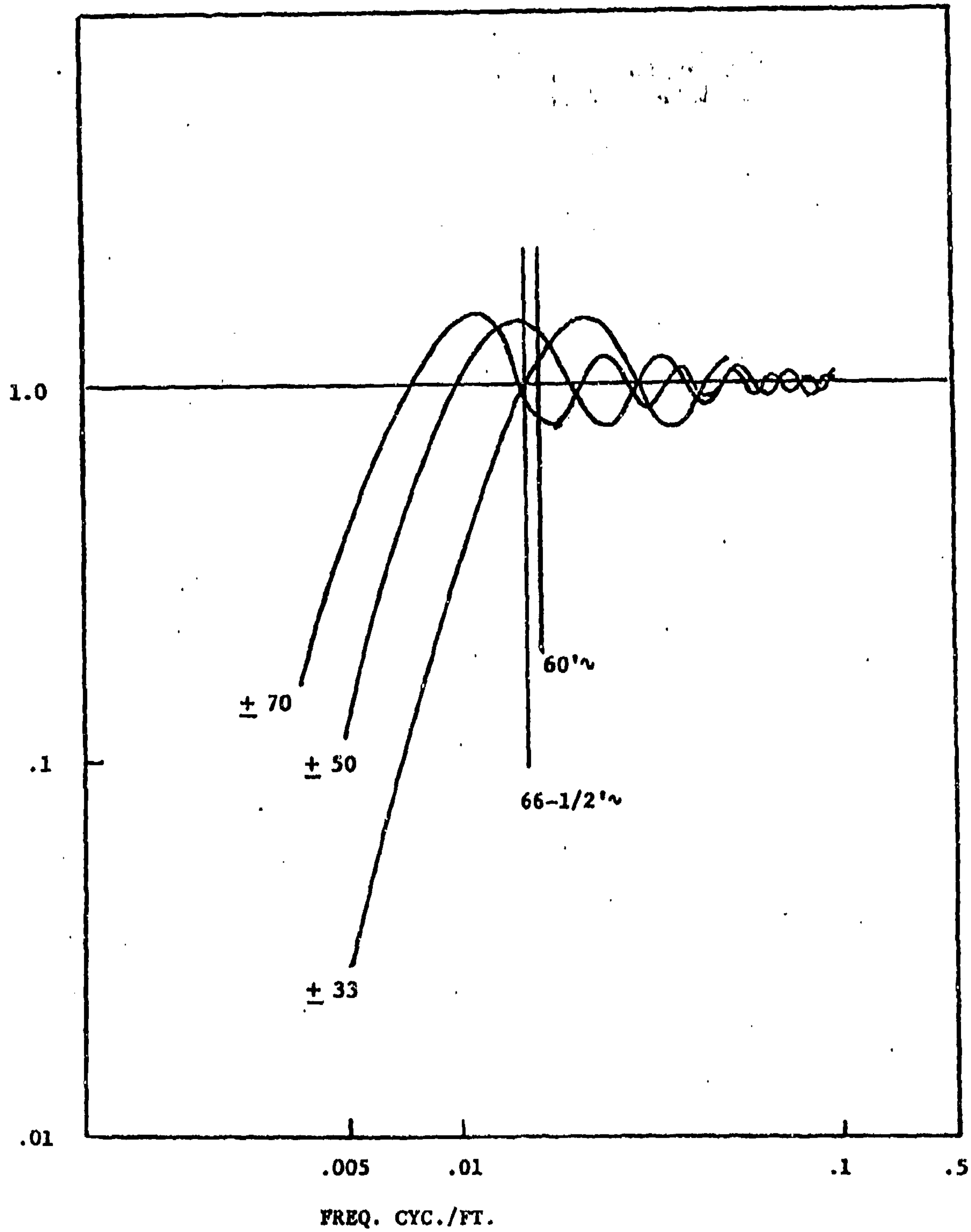

FIGURE 1

MOVING TWO SIDED

EXPONENTIALLY WEIGHTED AVERAGE

FILTER GAIN WEIGHTING CONSTANT CUT OFF AT SxY/L>3

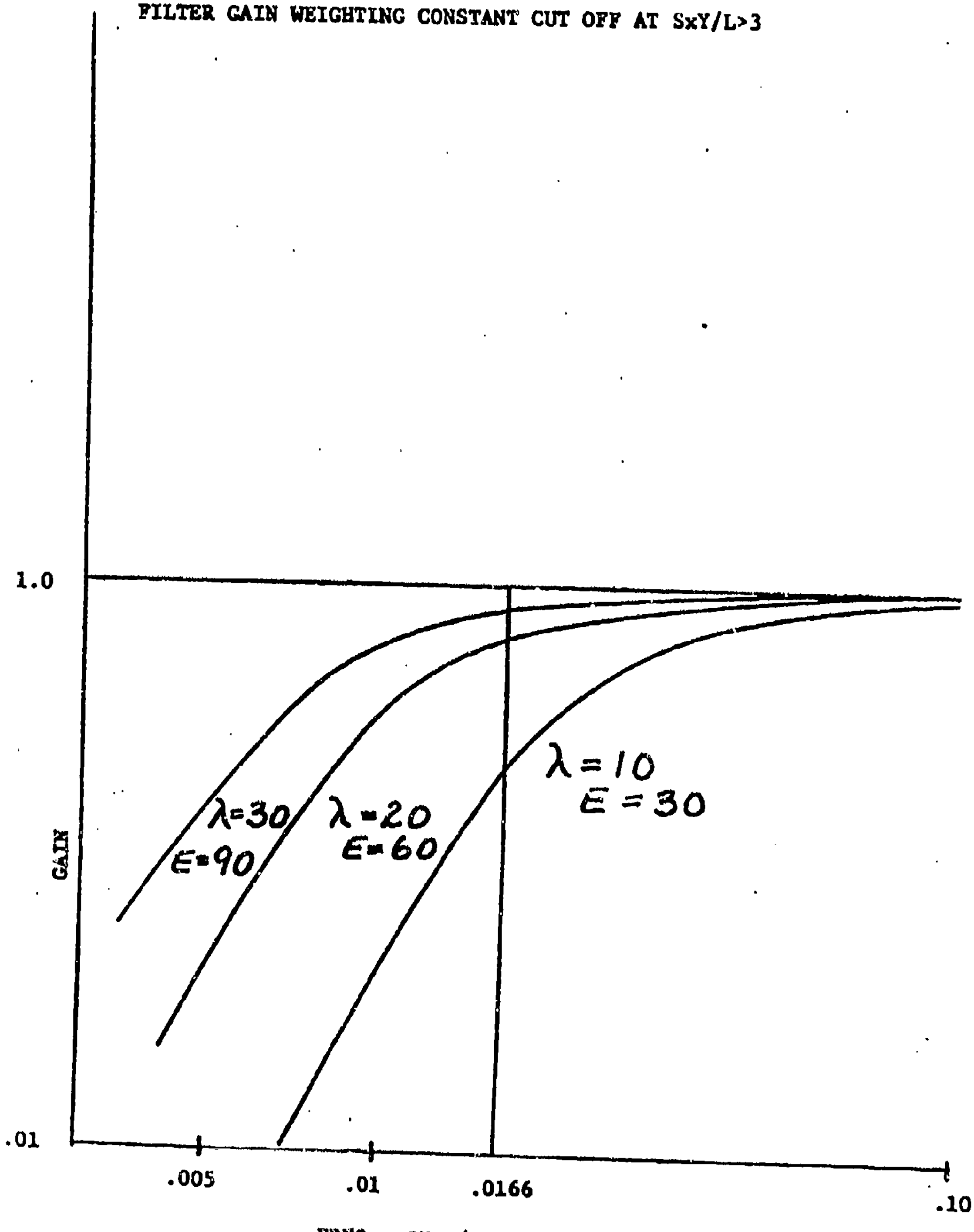

FIGURE 2

MOVING TWO SIDED

EXPONENTIALLY WEIGHTED AVERAGE

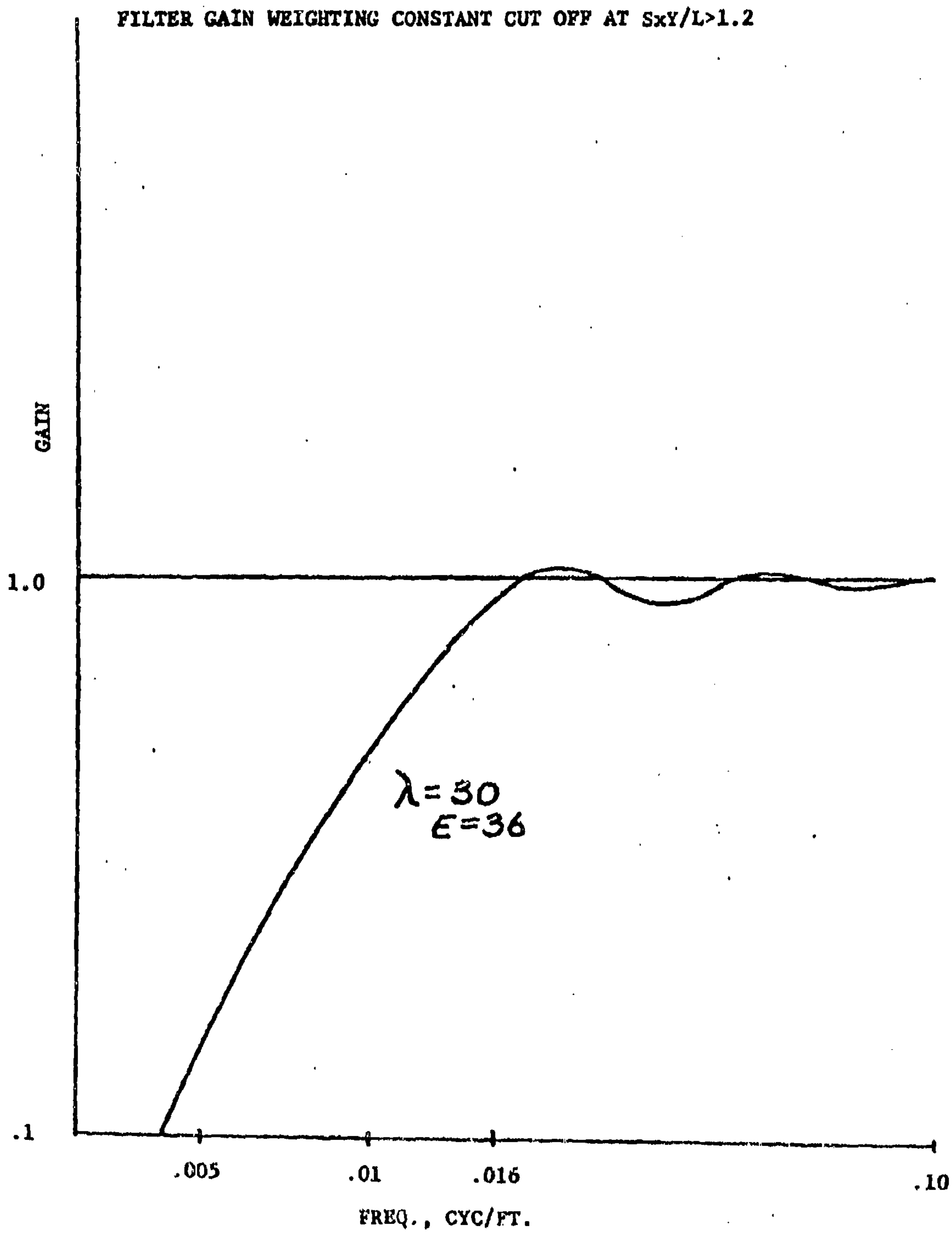

FIGURE 3

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Fast Fourier Transform, Signal Analysis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this report is to provide a user manual for the Signal Analysis Computer Program.

The TARADCOM Signal Analysis Program (formerly called the Fast Fourier Transform Program) was developed originally as a BASIC Wang Program by Robert Daigle and associates. The TSA computer program has been converted from BASIC to FORTRAN and various graphics

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displays, such as linear plot of evaluation vs. distance, a point plot of amplitude vs. periods, and a log-log graph of power spectral density vs. frequency, have been added.

Terrain data input to the program may be used in processing, rather than data equations that are contained in the program. Options available during processing include: first to last point detrending, digital high pass filters, exponentially weighted running average, no detrending, interpolation, amplitude smoothing, and a GEO window. The results of the TSAP include, besides graphics displays, amplitudes, periods, frequencies, power spectral densities, and RMS values.